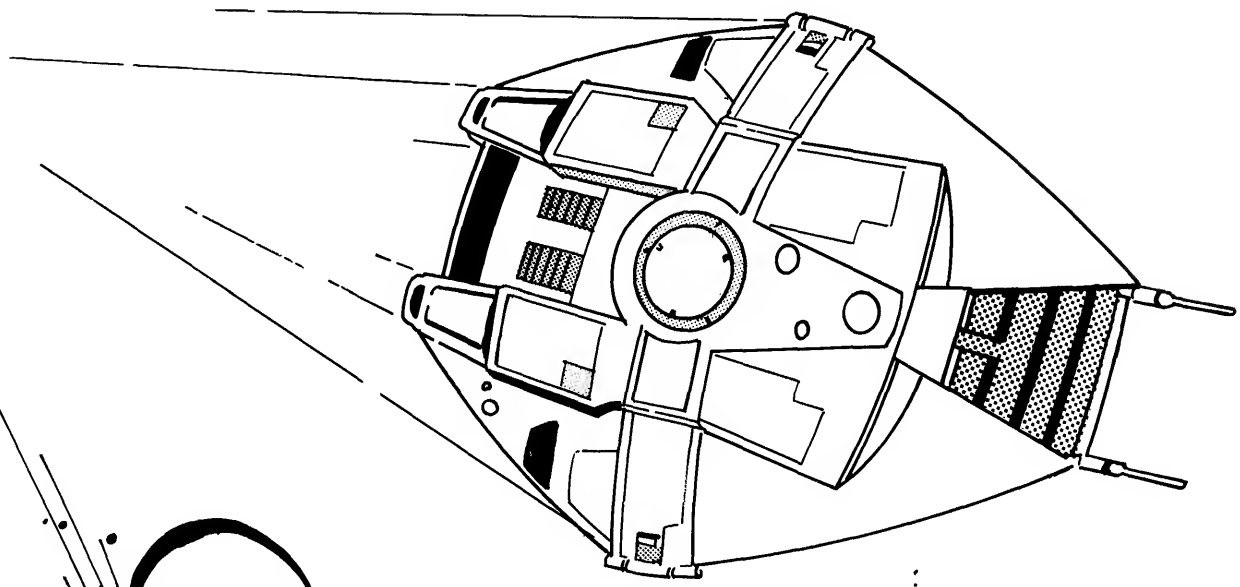
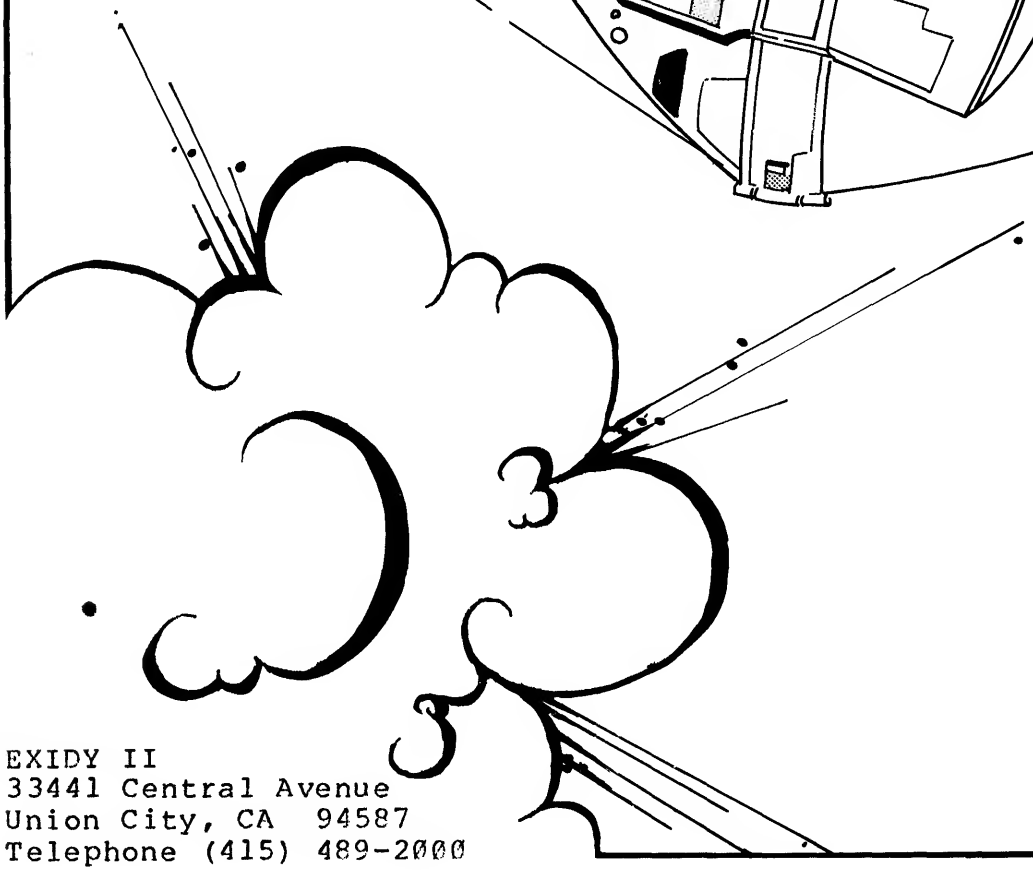
TAIL GUNNER 2





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TAIL GUNNER 2

Operator's Manual

January 1980

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I. INTRODUCTION

Tail Gunner 2 is a one player game with dual controls providing ease of operation for right and left handed players. The video display generates 2 levels of intensity, and the audio system generates 6 different sounds during play. The player has control over a moveable sight on the screen by means of a proportional joystick control, which is used for aiming at oncoming spacecraft as they appear on screen. The player has control, by means of a fire button, over a Phasor cannon which, when depressed causes two energy bursts, originating from the bottom corners of the screen, to intersect at the current location of the moveable sight and destroy enemy spacecraft.

The player also has control of an energy force shield. When this is activated, it appears on the screen and prevents any enemy spacecraft from passing by. Shield time counts down as used (at the rate of 5 units per second), and once the shield energy reaches zero the shield cannot be reactivated and the player must rely on his skill at destroying ships with his Phasor cannons to prevent any ships from passing by.

As soon as ten enemy spacecraft have passed off screen, the game is over. Spacecraft enter the screen in groups of three, and until all three have either been destroyed by Phasor fire or passed off screen, another group will not enter. As more ships are destroyed, the succeeding groups become more evasive and move faster.

After inserting the necessary amount of money (one or two coins), credits are displayed on the screen, and when the start button is depressed the game begins. The amount of shield energy can be changed by switches on the CPU Board, as can the amount of coins per credit.

A. Game-Set-Up

This section describes your Exidy II Tail Gunner 2 game, the selected location for your game, and how to inspect it. It also outlines the preliminary set-up procedure.

The Exidy II Tail Gunner 2 game is designed much the same as conventional video games. The major exception is the use of an alternate means of visual display...the patented Exidy II monitoring system.

However, the game is built of the same basic building blocks as any other video game:

The Power Supply provides all necessary voltages for each separate electronic assembly.

The Central Processing Unit contains circuitry to strobe and interpret all input functions which include the player control panel switches and all coin and credit information and generates all the digital signals used to provide the visual display and control the audio effects. It also contains all the software (i.e., machine language and game personality memory) needed to control the game operation and to generate the proper vectors for the display.

The Audio Board consists of a noise generator and wave shaping circuits which produce different game sounds on command from the CPU logic board.

The Exidy II Display Electronics is the final form of interpretation of the CPU's calculations. The CPU logic informs the display electronics unit of information regarding line length and line placement on the CRT. This is accomplished with two twelve-bit words each for horizontal and vertical deflection, and a number of other controlling signals for the cathode drive circuit and switching of the deflection circuits.

The major difference between the vector generator and raster scan type monitors is the means by which the cathode beam is directed (deflection) across the screen.

In the raster scan type of display, the electron beam from the cathode to the anode of the CRT is constantly deflected (scanned) across the face of the CRT in a series of horizontal lines that trace from the upper portion of the screen to the bottom in a synchronous pattern. Vertical information is forming a matrix-type pattern of mathematically possible illumination points on the face of the CRT. If the cathode current is increased at these points on the screen in matrix-type patterns (similar to placing dots on a piece of graph paper where the lines intersect) coherent video in the form of shapes and alpha-numerics to form game backgrounds can be displayed.

The vector generator takes a slightly different approach to cathode beam deflection. The results are a much higher degree of resolution and much smoother motion across the screen. Rather than using a constantly scanning cathode beam, the beam is directed only to points of eventual illumination, using a vectoring form of programming rather than a matrix approach. Basically, the cathode beam is directed between two determined points, and illuminates the entire path of phosphors between these two points, unless blanked by stopping cathode current (i.e. when the beam moves from one star to another on your screen). The ability to illuminate the entire path of phosphors crossed by the electron beam, in any direction desired, (which is not possible in a raster scan system) creates a much higher degree of resolution than can be found in a raster scan system while at the same time creating a much greater number of angle possibilities. This is also supported by the ability to accommodate two twelve-bit words of information, twelve each for vertical and horizontal deflection, and the fact that there is no background illumination from a constantly scanning beam when brightness is turned up. The higher degree of resolution combines with the totally blackened background generating an appearance of depth not found in a raster scan system.

B. Inspection

All Exidy II equipment is carefully packaged in well padded cardboard containers to prevent damage during shipment. If a component is noticeably damaged, notify the Exidy II Customer Service department for information concerning the disposition of the damaged component. DO NOT apply power to the game.

To ensure that the equipment has suffered no damage in shipment inspect the container prior to acceptance from the carrier. If no immediate cabinet damage is evident perform the following visual inspection.

1. Open the rear access door with the appropriate packaged key.

2. Examine each major and electrical component thoroughly for scrapes, dents, broken or missing parts and loose or missing screws.

3. Check for loose cable connectors.

4. Visually verify that all the integrated circuit devices (IC's) plugged into sockets are properly seated and that no IC pins are bent or misaligned.

   Figure 1 shows a side view of the Tail Gunner 2 cabinet with the rear access door opened and the slide drawer pulled out exposing the Tail Gunner 2 components.

Should any damage be discovered during the foregoing inspection, a claim should be filed with the carrier. A complete report of the damage should be forwarded to Exidy II.

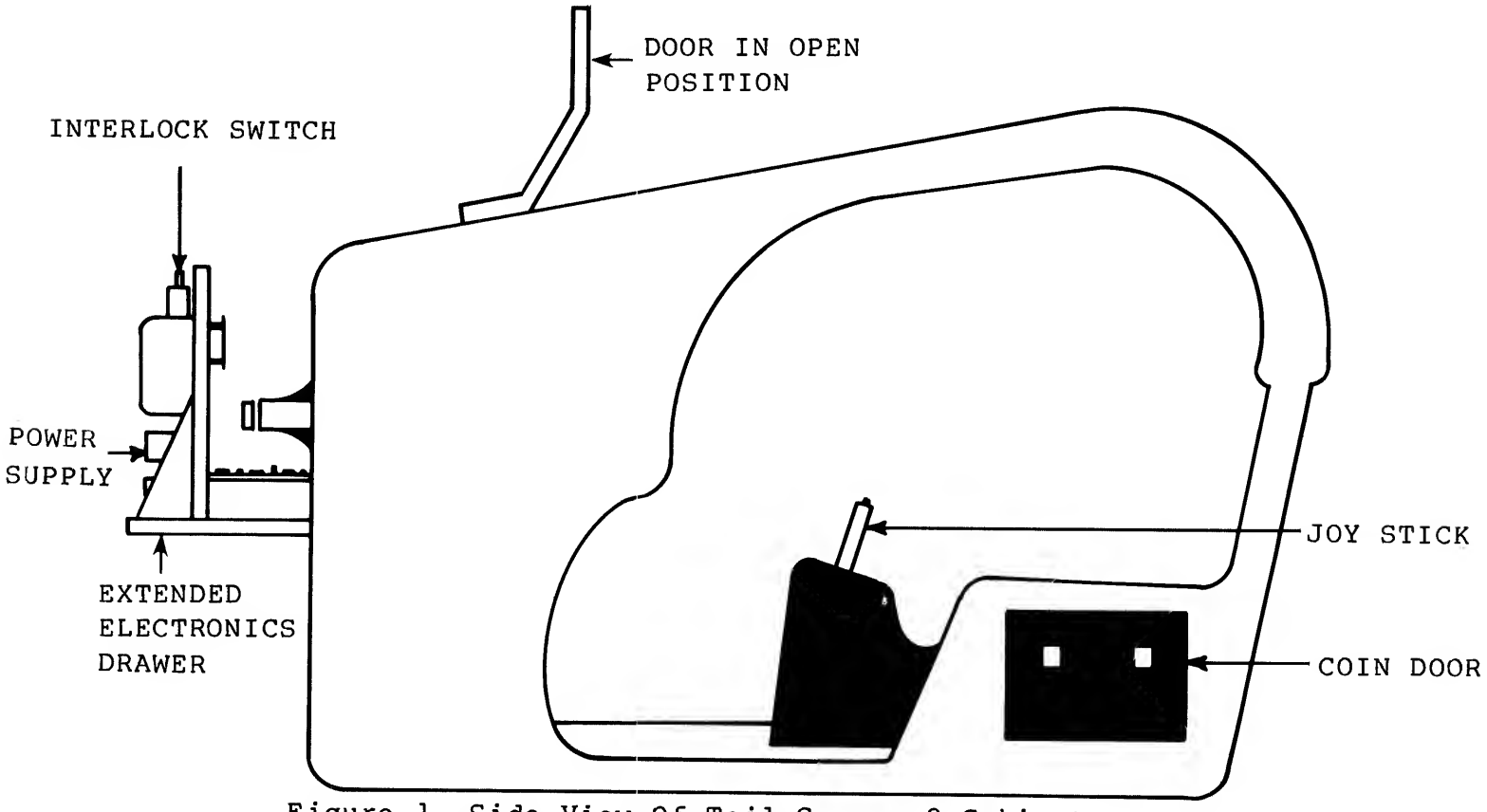


Figure 1, Side View Of Tail Gunner 2 Cabinet Showing Rear Access Door In Open Position And Extended Electronics Drawer

C. Installation

Planning the location of the game should involve both physical and electrical consideration. Physical considerations concern the placement of the equipment with respect to clearances, AC cable and environmental conditions such as ventilation, temperature, weight support and accessibility (although your game has the durability to endure nearly every type of physical hazard). Electrical considerations include availability of the correct voltage and frequency.

In planning this installation, consideration must also be given to working space required for personnel involved with operation or maintenance of this system.

NOTE: The cabinet must be within five feet of an AC outlet. Be certain that a ground jack or terminal is available at the outlet.

CAUTION: DO NOT remove the AC ground prong from the plug.

AC Line voltage Selection: AC line voltage selection is available in your Tail Gunner 2 game by setting the appropriate jumpers on the power supply chassis.

Table 1 lists the selectable jumpers for either 100 VAC, 115 VAC or 230 VAC. Always check for the correct AC line voltage with an AC voltmeter at the AC outlet.

Table 1: AC line Voltage Selection

Input Voltage	Jumper Terminal	Input Connection
100 VAC	1 to 2,3 to 4	1 and 5
115 VAC	1 to 2,3 to 4	1 and 4
230 VAC	2 to 3	1 and 4

D. Preliminary Checkout Procedure

The Tail Gunner 2 game, after it is properly installed, should be checked operationally by performing the following procedures:

1. Plug in the AC jack into the AC outlet.

2. Allow 1 to 2 minutes for CRT warm up.

3. Observe the TV monitor display to assure the correct Attract mode is present on the screen (the Attract mode is explained in detail in the Game Operation section).

4. If the Tail Gunner 2 Attract mode display is incorrect, contact Exidy II service department.

5. Insert quarter into either slot of coin mechanism. Attract mode should disappear and the game should be in the Ready-to-Play mode as described in the Game Operation section.

6. Proceed to play the game and verify that all screen images are displayed as shown in the illustrations of the Game Operation section.

If adjustments are necessary contact Exidy II service deparment.

E. Interlock Switch Checkout Procedure

The interlock switch has been provided by Exidy II to effectively secure a safeguard for the maintenance technician, while working inside the cabinet. When the PCB is pulled away from the mounting wall the interlock switch turns off the power to the unit. The switch should be checked for precautionary purposes by performing the following procedures while power is supplied.

1. Unlock the rear access door and lift gently to fully opened position.

2. Pulling out the interlock switch, located on the PCB wall will restore power to the game for test purposes.

3. Close and lock the rear access door.

F. Operator Option Switch

The following chart diagrams the switch setting of the option switches for Tailgunner. The 8-position DIP switch is located on the logic board. Table 2 shows all the operator option switch settings.

Table 2: Operator Option Switches

SWITCHES	SHIELD POINTS								OPTIONS: Coins per credit	
	15	20	30	40	50	60	70	80	1	2
Switch #1	ON	ON	OFF	OFF	ON	ON	OFF	OFF	X	X
Switch #2	ON	OFF	ON	OFF	ON	OFF	ON	OFF	X	X
Switch #3	X	X	X	X	X	X	X	X	OFF	ON
Switch #4	X	X	X	X	X	X	X	X	X	X
Switch #5	X	X	X	X	X	X	X	X	X	X
Switch #6	ON	ON	ON	ON	OFF	OFF	OFF	OFF	X	X
Switch #7	X	X	X	X	X	X	X	X	X	X

NOTE: ON = CLOSED = LOGIC Ø

OFF = OPEN = LOGIC 1

X = NO EFFECT

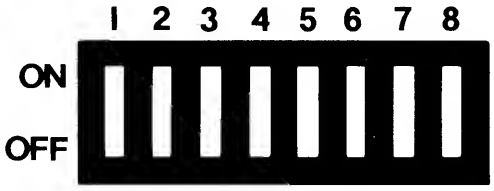


FIGURE 2, 8- Position DIP Switch

II. GAME OPERATION

The Tail Gunner 2 game has all the visual and audio effects a player needs to feel in command during a battle in outer space.

The following paragraphs explain the different game modes needed to be checked after either set-up or repair to ensure the game is operating effectively.

A. Attract Mode

On the TV Monitor Screen a dark background appears, stars seem to be drifting away from the viewer, giving the appearance of movement through space. A tiny rectangle appears in the middle of the screen, flopping end over end and growing larger. In the center of the rectangle the word TAIL GUNNER becomes readable. The rectangle continues flopping and growing in size, then disappears and reappears again in tiny form, repeating the above performance over and over. Enemy spacecraft dodge and dart about the screen, disappearing and reappearing.

A four digit high score is displayed in the upper right hand corner of the screen and the current score is presented in the upper left hand corner. The high score is zero when AC power is initially applied, otherwise the high score displays the last highest score. The high score is reset each time power is removed, then reapplied.

B. Ready-to-Play Mode

The game is set into the Ready-to-Play mode when the coin switch is activated by the insertion of a coin or coins. The word CREDITS preceded by a number indicating the number of games paid for shows in the bottom center of the screen. The word PUSH START is displayed in the center of the screen. On the upper right corner a zero appears. This number will inform the player how many enemy ships have passed off the screen as the game progresses. At the top center of the screen a number appears, showing the shield count. The shield count decreases to zero during play as the player hits the shield buttons which are located in the arm supports.

C. Play Mode

The play mode is triggered when the player presses the red PUSH START button located to the right of the joystick. A group of three enemy space ships drift into view slowly approaching the player. A gunsight type crosshair also appears on the screen and can be maneuvered by manipulating the joy stick. The red button on top of the joystick fires missiles at the enemy craft. When a missile hits an enemy ship, the ship explodes into fragments and disappears. If the enemy ships approach the side of the monitor too closely, a shield may be activated by pressing one of the shield buttons. The shield appears as a large grid covering most of the screen. The enemy ships deflect off the shield back into the center of the screen and then explode. During play various audio sounds appropriately accompany the game action. As ships pass off the screen the ship counter keeps track of the number of ships escaping. As a ship escapes the screen presents a pattern, briefly, then returns to the game action. When ten enemy ships have "escaped" by passing off the screen the game is over. The screen returns to the Attract mode.

D. TEST MODE

Test Pattern Recall Procedure:

1. Open the rear access door.
2. Plug the game AC plug into AC wall receptacle.
3. With right hand press and hold down the RED START button on the front panel.
4. With the left hand pull out the INTERLOCK SWITCH. The screen should display the test pattern. If not, try once more from step 3.

III. THEORY OF OPERATION

This section describes the principles of operation of the major circuit functions of the Exidy II TAIL GUNNER 2 Game. The system's general functional description is followed by detailed circuit schematics which are included as Appendix B. The schematics used in this manual are similar in nature to those used by most industrial electronic firms.

A. Monitor Display

The Exidy II monitor is unlike the conventional TV monitor in that it displays vectors (lines generated from X-Y coordinates received from the logic board. The horizontal points are X(width) and the vertical points are Y(height). The X and Y logic signals originate from the logic board.

The Exidy II monitor can be divided into two basic sections: one is the deflection amplifier and the other is the voltage and cathode drive circuits.

The deflection amplifier can be further divided into two identical channels: one for the vertical deflection and one for the horizontal deflection. The operation of the vertical channel will be discussed; however, the same theory of operation pertains to the horizontal channel.

Digital information, in the form of a twelve-bit word, is applied to the input of the DAC-8Ø digital to analog converter (U5) on pins one through twelve. The most significant bit is applied to pin one, and the least significant bit is applied to pin twelve. The DAC-8Ø makes the necessary conversion from digital signals to analog signals which are outputted as analog voltage signals on pin fifteen (proportional in level depending on the input word applied). The result is a positive and negative voltage signal about its reference voltage. Remember, there is no "sync" signal present, and the signal is not true video as seen in raster scan monitors.

From the DAC-8Ø the analog signal is then sent to a high-speed analog switch, (U3). The analog switch has two parallel inputs for the display signal, and two controlling inputs which select one of two outputs from the switch. An R.C. network, which is used to create line length and line position on the screen is found at the outputs.

Output fifteen from the switch routes the analog signal through a 5K potentiometer (R58), a 1ØK resistor, (R59) and to the input of U4 op-amp. The time constant developed by these two resistors and the capacitor (C35) determine the length of the vector line seen on the screen. Adjusting the potentiometer will adjust the length of the vertical lines seen on the screen.

Output ten from the analog switch routes the signal directly to the input of U4 op-amp, and the resulting time constant of the op-amp input impendence and the capacitor C101 determines the position on the screen of the vector lines.

Op-amp, U4, serves a dual purpose: it acts as a buffer between the deflection amplifiers and the analog switch, as well as an "edge gain" amplifier (i.e., height).

At the output of U4, there is a resistor diode network consisting of R50,51,56, & 57 and CR28-CR30. This resistor diode network is used to compensate for the non-linear characteristics of the CRT near the edges of the screen. If this circuit were not used, any object displayed on the screen would increase in size as it moved closer to the edges of the screen. Potentiometer (R54), adjusts the height of the pictures.

From the wiper of R54, the signal proceeds to Q17, which is the first state of deflection amplification. Q18 is an emitter coupled with Q71 to provide a degenerative feedback loop from the yoke. Q16 is used to provide a constant current source to both emitters.

At this point, the deflection circuit can again be divided into two identical circuits. One circuit, which controls the lower half of the screen, is comprised of Q8, Q9, Q10, and Q110. The other circuit, which controls the upper half of the screen is comprised of Q6, Q7, Q12 and Q111.**

Q8, Q10 and Q6 are three stages of amplification, while Q9 is used as current limiting protection for Q10 and Q110. The same holds true for the other configuration of Q65, Q7, Q12 and Q111. R23 through R28 are used as a current divider network for the yoke.

R40, R38, and C37 form a RC network, which compensates for any counter EMF that may develop by the expanding and collapsing of the deflection coil's electromagnetic field.

The high voltage and cathode circuitry is the second section of the monitor. This section also contains the necessary voltage regulation to power the ICs located on the display board as well as develop the high voltage.

U10 and U11 provide plus 15V and minus 15V respectively to power the DAC-80s and the TL081 op-amps on the display board.

U9 and U12 provide plus 18V and minus 18V used in the high voltage transformer (T-1) and oscillator (the oscillator circuit is necessary because there is no horizontal sync. used to develop the high voltage pulses.) The oscillator circuit is comprised of primary windings, Q31 and associated discreet components.

The high voltage 18KV is developed by T1 secondary windings, and the high voltage tripler.

The intensity and beam blanking control circuitry is composed of U6, Q19, Q20, Q21, Q22 & Q24 and associated components. The cathode voltage rides at +88. The beam is turned on by a more negative voltage. At the anode of CR51 negative pulses can be seen, these are the beam on pulses. For normal intensity the pulses will go down to approximately 40V, for double intensity, 20V. Pins 3 and 4 of U6 is the normal intensity control gate which receives information from the CPU. Pin 1 and 2 is the double intensity control gate. When a Hi going Lo signal is on pin 3 of U7 pin 4 will be a Lo going Hi turning on Q22 on the Hi transition. Q22 acts as a switch connecting the series network of R91, R79 and R78 to ground creating a voltage divider network. R11 is the manual intensity control. When 2 of U6 goes Hi Q20 turns on for the duration of the pulse connecting just R78 and R91 to ground, thus lowering the voltage at the anode of CR51 lower still because of the lower resistance, than with normal intensity. Q24 is used as a switch to enable Q20 and Q22. Its purpose is to shut off the beam when the power is turned off. Q21 is a beam on delay to prevent phosphor burns if someone was to unplug and plug in the machine rapidly.

R111 is the brightness potentiometer, which adjusts the amplitude of the negative spikes used for brightness and intensification.

**In the horizontal section of the deflection amplifier, Q3, Q1,Q2 and Q210 control the left hand side of the screen, and Q45, Q11, Q5 and Q211 control the right hand side of the screen. By dividing the screen in this manner, four quadrants of deflection area have been developed (refer to Vector Generator description).

B. CPU Board

The processor hardware can be broken down into five basic functional blocks. The ALU and Control block are the main components of the processor while the Memory and I/O blocks may be thought of as merely peripherals..

The following is a brief description of each block.

RAM (6)

The RAM is implemented with three read/write static memories configured as a 256 x 12 bit block. Data can be transferred to or from this memory via the ALU block. The processor uses this RAM as a scratch pad.

ROM (1Ø)

The ROM is configured as an 8K x 8 bit block of memory. These memory locations contain the program instructions and/or data. It is accessed via the processor control unit.

I/O 19,17,18

The I/O block consists of 8 output lines implemented with a bit addressable latch, 24 input lines implemented with data selectors, and two 12 bit registors which are connected to the X Y display deflection circuits via D/A convertors.

Arithmetic Unit 1,2,3,4,5

The arithmetic unit performs all the arithmetic processing for the system. It consists primarily of two 12 bit accumulators, an arithmetic logic unit and various data selectors. The accumulators can function as temporary storage registers for arithmetic functions upon the data in the accumulators. The data selectors are used to select the various sources of data which will be processed.

Control Unit (15,16,14,7,8,9,11,12,13)

The control unit is the heart of the processor. It performs all instruction decoding operations and generates all the necessary control signals which the rest of the hardware requires to function correctly.

1. Accumulator Selector

The accumulator selector consists of 3 quad data selectors. They are used to select the output of either the primary or secondary accumulator for processing by various other sections of the systems.

2. 2 & 3 Primary and Secondary Accumulators

The two 12 bit accumulators are implemented with quad bidirectional shift registers. The primary accumulator consists of S4,P4,M4. The secondary accumulator consists of T4,R4,N4. All data manipulation in the processor is accomplished using these two accumulators. All output data flows through these registers.

4. Arithmetic Logic Unit (ALU)

The ALU is used to perform all necessary arithmetic functions within the processor. The ALU is implemented using three 24LS181 (N6,M6,L6) function generators, three 74LS85 (N9,M9,L9) 4 bit magnitude comparators, and a 74LS182 (L4) look ahead carry generator. The data which the ALU manipulates can come from four different sources. The first source is the contents of the accumulators via the accumulator selector. The second and third sources are the ROM and RAM data outputs via the ALU data selector (N11,M11,L11) and the fourth source is the external input selector (E4,D4,C4).

5. Data Selector

The data selector is used to read data into the ALU from either the RAM or ROM memory. Note that the ROM data is only 8 bits wide while the RAM data is 12 bits wide.

6. RAM Storage

The system RAM consists of three 91Ø1C high speed static memory chips connected as a 256 x 12 bit block. The block is 12 bits wide in order to allow the contents of an accumulator to be stored. The processor uses the RAM as temporary storage of program variables, data pointers or any other data of a dynamic nature.

7. RAM address Selector/Register

The output of this register is tied directly to the address lines of the RAM. It consists of a multiplexer which routes address data from either the ROM or RAM locations to the RAM address lines. The capability to use RAM data to select RAM addresses is the basis for the indirect addressing mode of the processor.

8. Page Selector

The page selector is used to latch the high order 4 bits of a RAM access instructions.

9. ROM Data Register

The register is used to temporarily hold data from the ROM during an instruction fetch.

1Ø. ROM Memory

The ROM memory consists of the actual memory chips plus a data selector and latch circuit. The latch is used to improve the memory access time during a two byte instruction fetch by allowing one byte of the instruction to be latched while the RAM address lines are decoded for the other byte. The data selector can then be used to rapidly access both bytes of the instruction by switching between the latch and memory outputs.

11. Instruction Register

The instruction register is a latch which holds the current op code as read from ROM. Its output is tied to the instruction decode circuitry which in turn generates the necessary signals to execute the instruction.

12. System Sequencer

The system sequencer is used to decode an instruction op code and to generate the appropriate timed sequence of signals which execute the instruction. The op code is decoded by using it as the address data to a set of decoder ROMS. The outputs of the decoder ROMS are then synchronized with the system clock and used to control the various system functional blocks.

13. Line Length Counter

The line length counter is used during the process of drawing a vector to control the length of a vector, by turning off the beam at a pre-determined time after the vector is initiated. The counter is loaded with a value from a line length ROM and then counts up until it overflows which in turn generates a signal to indicate the vector has geen finished.

14. Program Address Selector

This selector is used to provide the address data to the program ROM. It selects either the program address counter output or the accumulator selector output and routes this data to the ROM address lines. The ability to use the accumulator contents as address data allows the program to randomly access data tables stored in the ROM or to compute a branch address after a conditional test.

15. Program Address Counter

This is a 12 bit counter whose output defines the next location in ROM to be accessed. It is normally clocked sequentially to step through a program. However, it can be loaded with data from the program address register which is how the jump instructions are implemented.

16. Program Address-Register

This register is a latch used for temporary storage of an address which will be loaded into the program counter during a jump instruction. The input data to this latch can come from either the program ROM or the scratch-pad RAM.

17. Imput Selector

The input selector is used to read the state of one of the 24 input lines into the selected accumulator. There are 16 primary inputs and 8 secondary inputs. During an input instruction the upper 11 bits of the accumulator are set to zero while the least significant bit reflects the state of the input line. All input lines have pull up resistors on them so that they will read high if they are left unconnected.

18. Output Selector

The output selector is a bit addressable latch used to control the 8 output lines. During an output instruction the selected output line is set to the complement of the least significant bit of the accumulator. The output lines are used to control the audio board, display intensity and the mechanical coin counter.

19. Display Registers

The display registers are the interface between the processor and the display driver circuits. These registers are latches into which the contents of the accumulators can be stored. The outputs are ties to D/A converters which provide the input voltage to the display deflection amplifiers.

C. Audio Board

The sound generation circuitry is composed of the following functional blocks: Audio Power Amp with volume control, Explosion sound, Wideband Noise Generator, Background Rumble, Force Shield Hum, Shield Bounce, Hyperspace, and Phasor Cannon sound. All discrete sounds are tied together at a summing junction and then fed to R7Ø (The input to the power amp). Each sound is triggered by a low going digital pulse from the trigger port (IC23), which is software controlled by the CPU Board.

Functional Blocks

Each functional block is listed on SD205200 by its functional name (Example: Explosion) The Power Amplifier is composed of IC19,Q6,Q7,R75 and their associated components. IC19 is a preamplifier which directly feeds the push-pull power amp, Q7 and Q6. Adjusting R75 will change the amount of feedback to the preamp causing an an increase or decrease in volume at the speaker. UNDER NO CIRCUMSTANCES SHOULD THE POWER AMPLIFIER DRIVE A SPEAKER OF LESS THAN 8 OHMS IMPEDANCE.

The Wideband Noise Generator is a common signal source for providing wideband random noise to the discrete audio sections of the board. The noise generator works as follows: diode D1 is a zener diode with random noise levels of typically 200 micro volts generated at its internal junction. This noise will be present at the anode of D1 across resistor R1. The noise is amplified by a factor of 1000 by IC1 and coupled to IC2. IC2 is a band equalizing signal limiter which will balance out the amplitude of the noise frequencies by amplifying the weaker signals and attenuating the stronger signals. The output of IC2 should appear as wideband clipped noise with an amplitude of 1.2 volts peak to peak. IC3 will amplify the noise to approximately 5 volts peak to peak at which time it is ready for use by the sound circuits.

The Explosion sound functions as follows: Wideband noise is filtered by IC9, which is an op amp integrator, and injected into pin 2 of IC10. A negative going pulse of approximately 400 ns from pin 4 of IC23 fires a one shot, IC12. The output of IC12 then goes to 5 volts for a time determined by the RC time constant of C15 and R39. This brings Q3 into conduction charging C16 to +5 volts, turning on IC10. Once the pulse from IC12 has ended, IC16 will discharge to minus 15 volts causing decaying explosion sound as IC10's output amplitude fades.

The Background Rumble sound utilizes the explosion circuit just explained. By maintaining a low level output from the trigger port on pin 5 of IC6, Q5 is kept in conduction causing IC10 to conduct at a low level of amplification, which is determined by the value of R43. This allows a low amplitude level of noise to be constantly heard at the speaker.

The Shield Hum sound is composed of two 555 square wave oscillators IC16 and IC17. The output of each oscillator is fed into a RC filter network where the square wave is converted into a sinusoidal waveform. The outputs are then combined at pin 2 of IC13. Whenever pin 13 of IC4 goes to a low logic level, Q5 conducts turning on IC13 at an amplitude level determined by the value of R47 until pin 13 of IC4 goes back to a high logic level.

The Shield Bounce sound functions in nearly the same manner as Shield Hum. Two 555 oscillators feed 5 volt square waves into their corresponding dividers IC18. Then the outputs are combined at pin 2 of IC22. Filtered wideband noise is also injected at pin 2 of IC22. IC12 is a one shot which is triggered from IC23. When pin 12 goes to a low lever, Q8 conducts charging C44 to +5 volts and turning on IC22. When the one shot resets it turns off Q8. C44 then discharges to minus 15 volts creating a decaying envelope out of IC22.

The Phasor sound is created by ramping a VCO (IC11), from a high frequency to a low frequency while feeding the signal into a divider (IC8). When pin 4 of IC4 goes to a low level, pin 6 goes low enabling 1/2 of IC8. At this time pin 4 of IC6 goes from its low state enabling C13 to charge, which changes the voltage at pin 3 of IC11 causing the frequency shift. The output signal is then converted to a 5 volt square wave by Q1 and fed into IC8 through IC5. The digital outputs of IC8 are fed into R35-38 and R21, R22, and C8 converting them into an analog signal. When pin 4 of IC4 returns to a high logic lever, IC8 is disabled permitting no sound out and C13 is grounded through IC6 causing the VCO to return to its highest frequency.

The Hyperspace sound is created in the same way as the Phasor sound except that instead of low frequency sweep it goes from a low to a high frequency. When pin 1 of IC4 goes low, pin 3 goes low, enabling 1/2 of IC8. Pin 6 of IC5 goes high and pin 1 of IC6 goes low discharging C6 which sweeps the VCO. The rest of the circuitry is identical to the Phasor sound.

The Trigger port is an 8 bit addressable latch whose inputs come from the output latch on the main logic board through a ribbon cable to J4. The outputs of IC23 are at a high level until the proper commands are received from the CPU board. All sounds are low level actuated.

C. Audio Board

The sound generation circuitry is composed of the following functional blocks: Audio Power Amp with volume control, Explosion sound, Wideband Noise Generator, Background Rumble, Force Shield Hum, Shield Bounce, Hyperspace, and Phasor Cannon sound. All discrete sounds are tied together at a summing junction and then input to the power amp. Each sound is triggered by a low going digital pulse from the trigger port, which is software controlled by the CPU Board.

Adjusting the Volume

Adjusting the pot on the Audio board will change the amount of feedback to the preamp causing an increase or decrease in volume at the speaker. Under no circumstances should the Power Amplifier drive a speaker of less than 8 ohms impedance.

D. EPROM BOARD

The PROM board is a temporary board which contains all the program memory for the logic board in programmable read only memory devices. Eventually Exidy II will be as thoroughly satisfied with the program as you are and generate a pair of proprietary ROM's which will fit into their appropriate sockets presently located on the logic board.

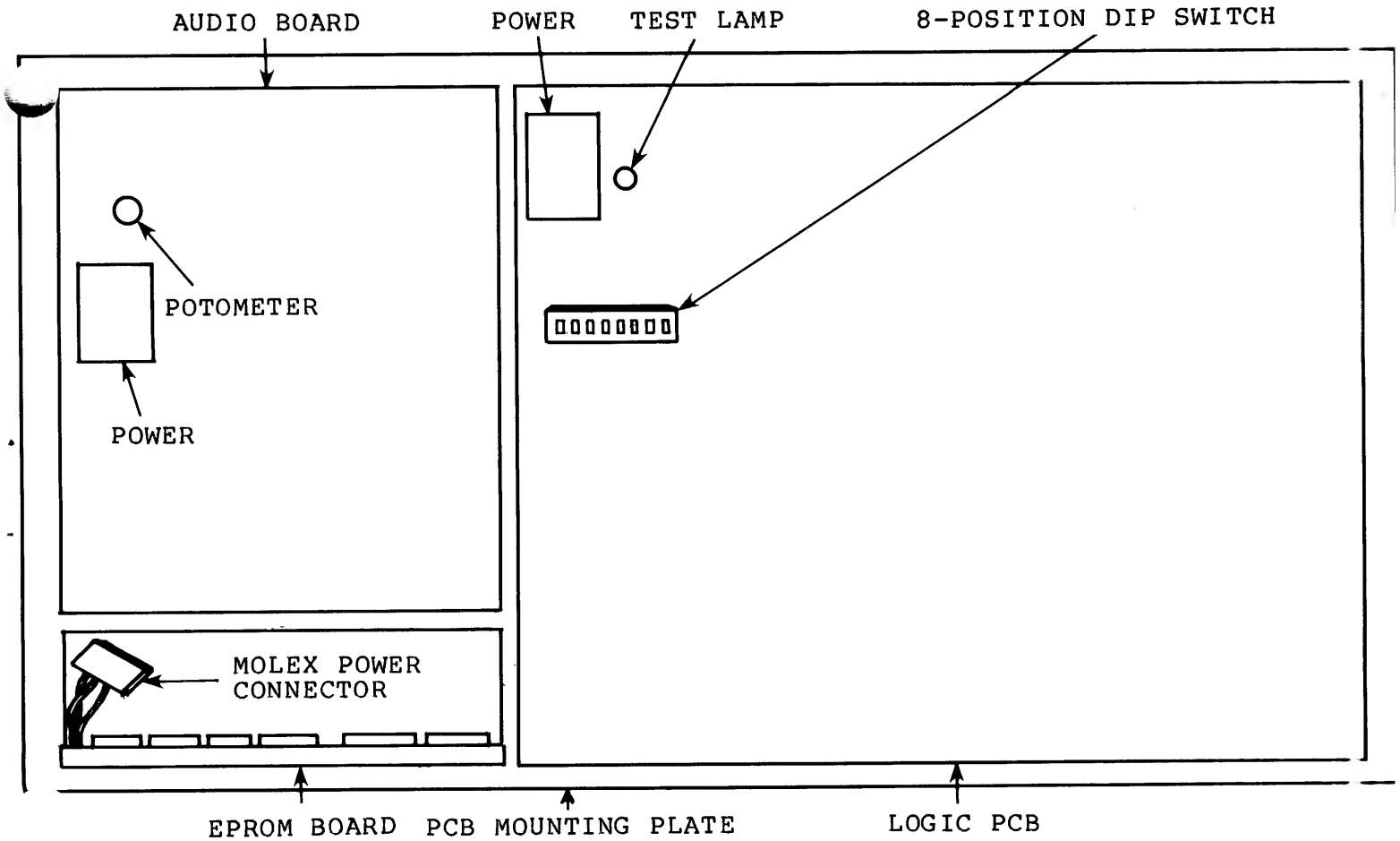


Figure 3, Tail Gunner II PCBs

E. Joystick Control Circuitry

The joystick circuitry is used in conjunction with the CPU Board to perform an analog to digital conversion. The X & Y pots on the joystick control work in the same manner with identical circuitry. One end of each pot is connected to +15 and the other end to -15V. The center wiper of each pot goes to its corresponding circuitry. The voltage off the pot is fed into the input of a noninverting DC amp, the capacitors on the input are used to smooth out the response when moving the joystck quickly to prevent jerkiness, then into a comparator. The other input to the comparator comes from the horizontal digital to analog converter on the display board. The comparator is comparing these two signals and feeding them back into the CPU. The 74Ø6 is being controled by the CPU to select either the X or the Y signals. The CPU reads the signal from the comparators. For example: take the vertical pot; if the joystick is moved left the voltage changes and is compared with the output of the DAC, which reflects the actual location of the sight on the screen. Then the comparator reflects the difference and feeds it to the CPU, which then reads this change and outputs to the display board a new location for the sight, in proportion to the speed and location of the pots on the joystick control. This new location is fed back to the comparator on the joystick circuitry and compared again until location matches the position of the joystick control.

IV. MAINTENANCE

Troubleshooting Guide

Problem	Probable Solutions
No Picture	Listen for audible "clatter" from the Vector circuitry on the display board. If the clatter is present, then the DAC's and the analog switch are operational and the problem is in the intensity circuitry
	If game audio is present, the problem is in the monitor. If the audio is distorted or absent, the problem is usually on the logic board.
	Check the neck of the CRT for a glowing filament. If there is no glow check the black and brown wires of the CRT connector for 6.3 VAC between them.
	Be sure all connections are made to the display board and CPU.
	Connect a scope to the yellow wire leading to the CRT connector. Set brightness full clockwise. There should be data pulses of 50 volts P-P at an 80-100 volt base. If no data pulses are present, connect a scope probe to pin 2 of IC U6 and check for data pulses. If data is present, check Q19 and Q20 with an ohmeter or a transistor tester.
	Check CRT neck for broken pins or other damage.
	Check the seating of the CRT plug and insure that proper connections are being made.
Narrow line on display	Check for an open winding in the yoke coils.
	Check for bad connections of yoke wires to display board.
	Check for continuity between display board and power transistor on heat sinks. Check for faulty power transistors. Also check for broken solder connections on circuit board molex connector socket pins.
Half of picture missing	Left half: Check Q2,Q1,Q210 Right half: Check Q5,Q11,Q211 Top half: Check Q12,Q7,Q111 Bottom half: Q10,Q9,Q110

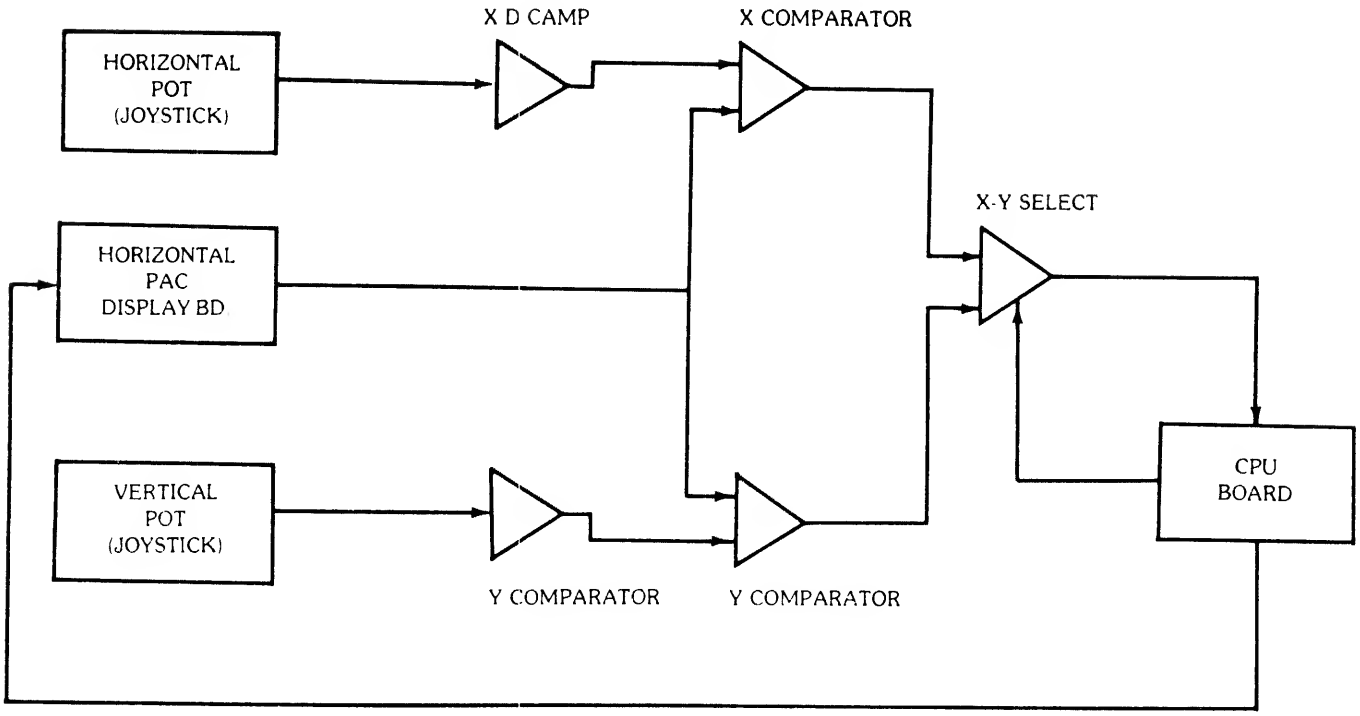
No brightness control.	Check intensity pot R91 for open wiper or internal short. Check for open capacitor. Check for bad solder connections to R91.
Circuit Breakers Trip	Disconnect power to display board. If circuit breakers continue to blow, check for a shorted speaker coil. Verify that the +15 and -15 volt regulators are operating properly. Verify that the output power transistors on the audio board are good with an ohmeter or a transistor tester.
	Disconnect the CRT yoke wires from the display board and remove CRT socket. Re-apply power to the display board and reset circuit breakers if necessary. If the breakers do not blow then check transistors Q2, Q5 and Q3 in the horizontal deflection circuit and transistors Q10, Q12 and Q8 in the vertical deflection circuit with an ohmeter or transistor tester.
	Check the horizontal and vertical DACS for proper supply voltages at pins 13,14, and 22.
	Measure outputs of amplifiers U102 and U202 with a scope for A+2 volt P-P signal centered at zero volts.
Picture on display jitters	Check the vertical size adjustment R54 for wiper noise by turning the wiper briskly while observing the screen. Then readjust for proper screen size.
	Check for bad solder connections on R54.
	Repeat the above two steps for horizontal size adjustment.
	Check DAC U5 for bad solder connections.
	Check all molex connectors for good connections.
	Check analog switch U1 for faulty operation, loose connections to socket or poor solder connections.
No high voltage	On display board, check DC voltage output of IC U9. It should be +18 volts DC. If not present, check for -25 volts present at the input to U9.
	Lift the winding from pin 3 of the high voltage XFMR T1. Measure +18 volts. If the +18 volts is present, check for a shorted Q31, shorted capacitors, bad diodes.
	Check for 6 kilovolts at black wire of XFMR T1.

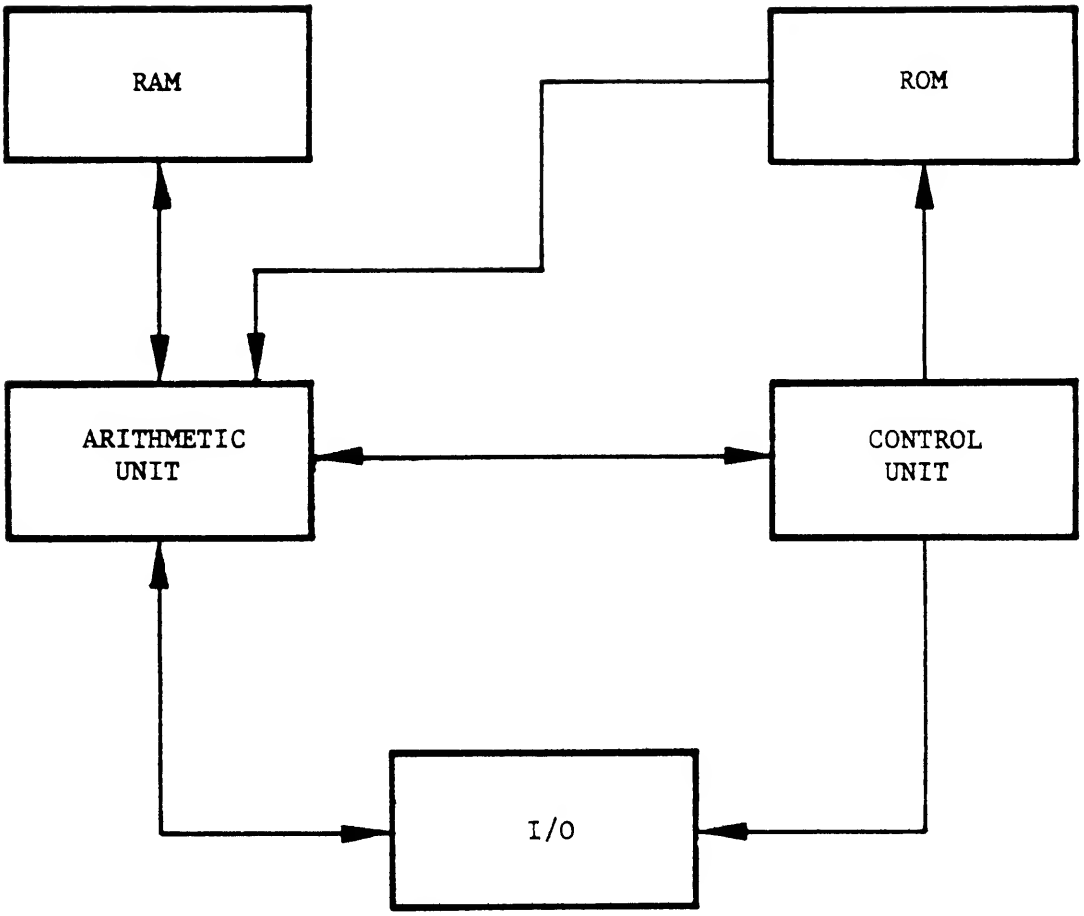
Dotted display	Check for faulty analog switch U3. Inspect yoke connections to display board. Check for open yoke windings. Check for proper +25 and -25 volts DC. Check operation of DACS U1Ø1 and U2Ø1.
No audio sound	Check for an open speaker coil. Check transistors 2N6292 and 2N61Ø7 and other nearby output components on audio board with an ohmeter or transistor tester. Check for open wiper on volume control of audio board. Verify that CPU is fully operational.
Coin counter is inoperative	Check transistor 2N6292 on logic PCB with ohmeter or transistor tester. Disconnect coin counter molex connector. Measure DC voltage on red wire. Meter should read +25 volts DC. Check power connector (J1) to logic board. Check electrical connection.

APPENDIX A: Theory of Operation

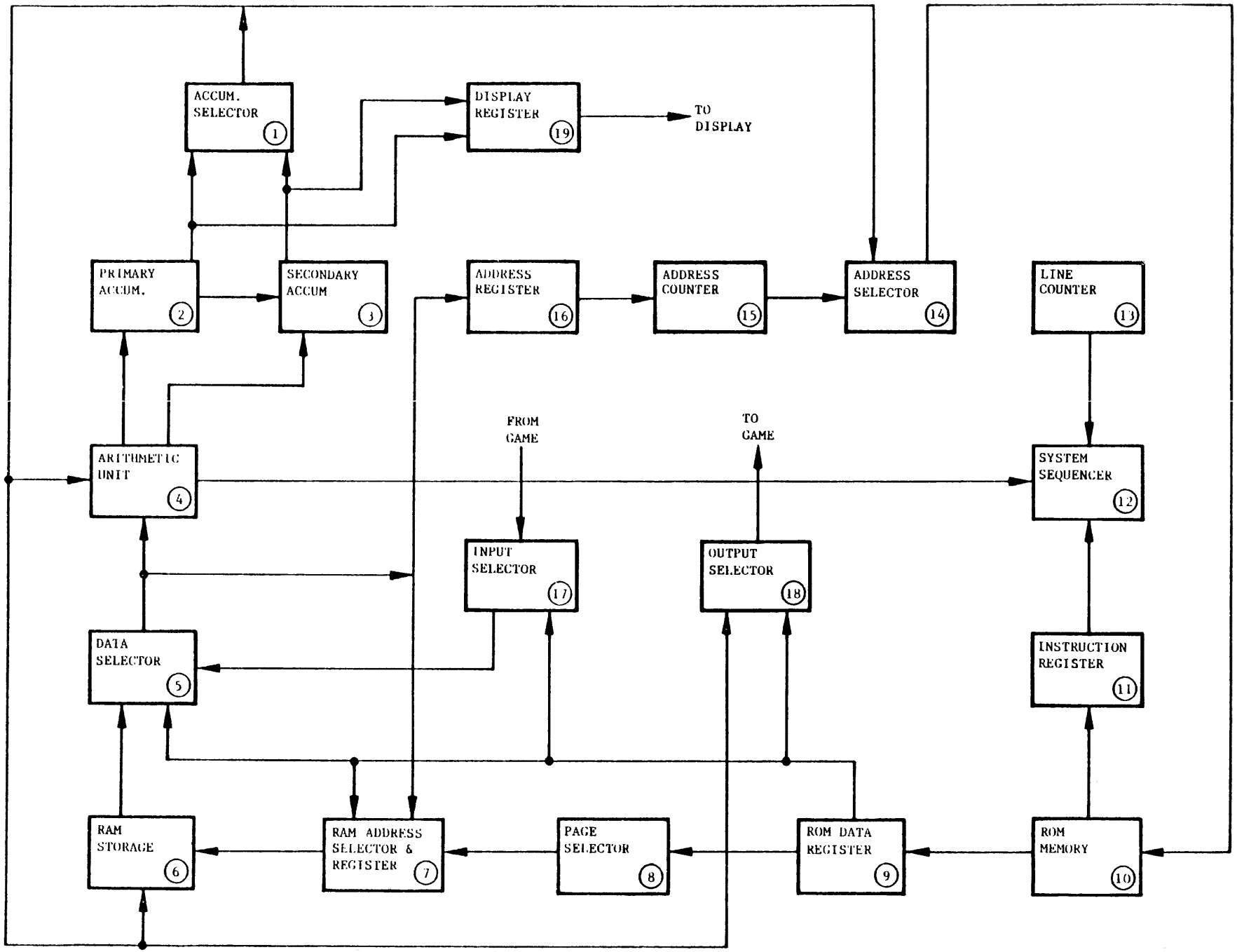
Block Diagrams

BLOCK DIAGRAM JOYSTICK CONTROL CIRCUITRY





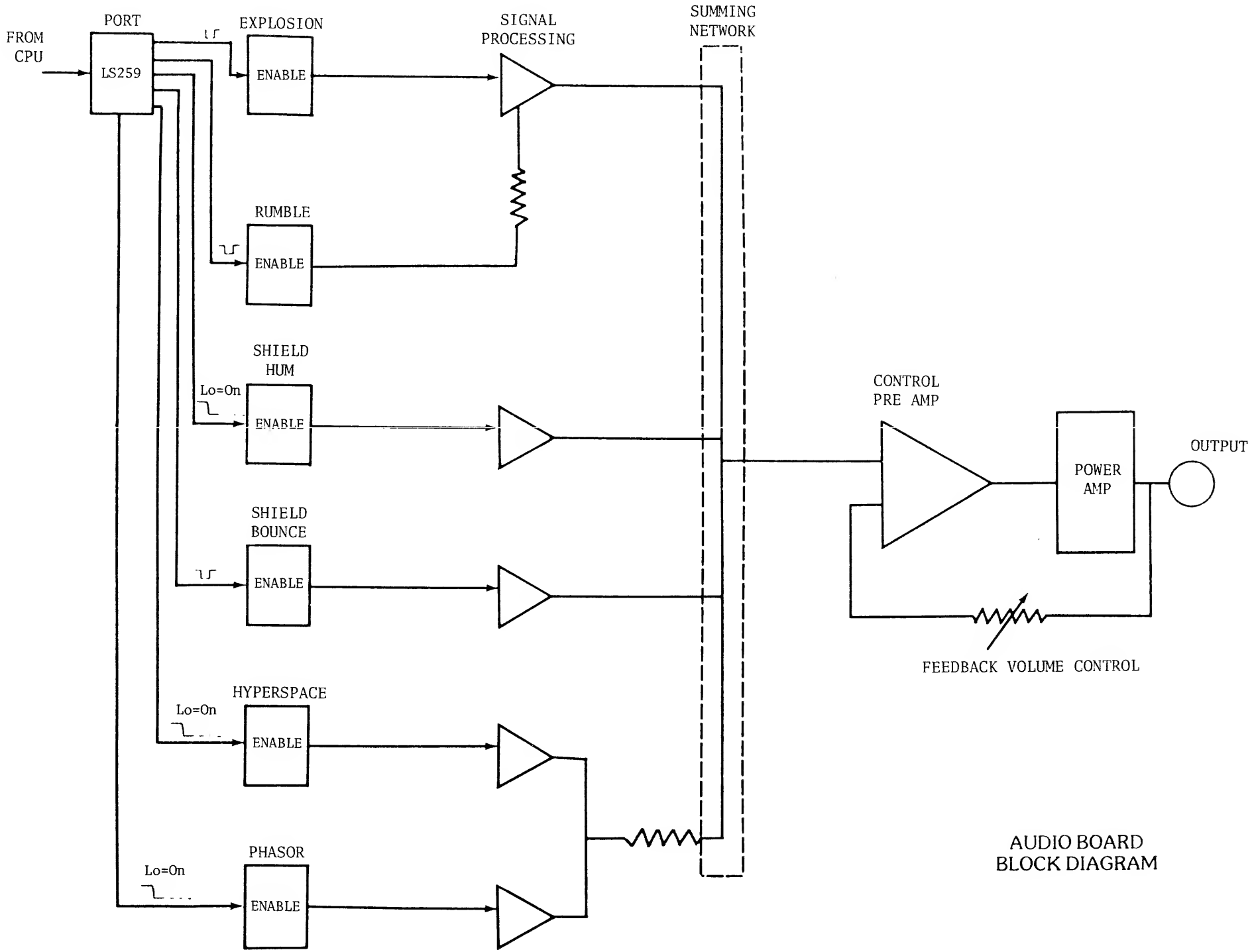
FUNCTIONAL BLOCK DIAGRAM



De ed Block Diagram

BLOCK NUMBERS AND COMPONENT I.C.

1. T-2, R-2, N-2
2. S-4, P-4, M-4
3. T-4, R-4, N-4
4. N-6, M-6, L-6, N-9, M-9, L-9
5. N-11, M-11, L-11
6. N-14, M-14, L-14
7. J-12, I-12
8. H-12
9. S-13
10. U-7, R-7, T-7, P-7, U-9, T-9, U-11, T-11
11. T-13
12. A-8, G-10, F-10, G-14, F-14, E-14, D-14, C-14
13. E-6, D-6, E-8, H-8, G-8, F-8
14. S-9, R-9, P-9
15. S-11, R-11, P-11
16. P-13, R-13
17. E-4, D-4, C-4
18. F-2
19. S-2, R-2, M-2



AUDIO BOARD
BLOCK DIAGRAM

APPENDIX B: Selected Parts List

Artwork Group

PART NO.	DESCRIPTION
22-10987-01	decal, right side, TAIL GUNNER
22-10987-02	decal, left side, TAIL GUNNER
22-10985-01	lab, overlay, logo panel
22-10458-01	lab, serial number
22-10288-01	lab, patent notice
22-10287-01	lab, safety ground notice
22-10289-01	lab, unit wired for

Plex Group

PART NO.	DESCRIPTION
21-10984-01	plex, canopy acrylic, Exidy 75-5155-12
21-11007-01	plex, blue panel
21-10986-01	plex, display panel, silkscreened

Fab Group

PART NO.	DESCRIPTION
20-10981-01	fab, coin box, Exidy 68-6050-10
20-10982-01	fab, coin box cover, Exidy 68-6050-20
20-10983-01	fab, hasp, coin door, Exidy 68-7100
20-11003-01	fab, bracket, display panel, upper blk
20-11004-01	fab, bracket, display panel, lower blk
20-11006-01	fab, bracket, upper canopy, black
20-11010-01	fab, bracket, PROM board
20-11005-01	fab, bracket, logo panel, plated
20-11011-01	fab, panel, floor grid
32-10977-01	fab, cabinet TAIL GUNNER 2
32-10977-03	fab, back door TAIL GUNNER 2
21-10574-01	fab, bezel
20-10758-01	fab, cover back door

Assembly Group

PART NO.	DESCRIPTION
38-11009-01	asy, electronics drawer
38-11016-01	asy, universal coin door, comp
38-10973-01	asy, Gimball joystick
38-10988-01	asy, armrest control
38-10422-01	asy, speaker
38-10522-01	asy, PROM board
87-11001-01	asy, interconnect harness
87-11014-01	asy, bottom, ground braid harness

Miscellaneous Group

PART NO.	DESCRIPTION
25-10270-01	lock, back door
25-11035-01	rubber, bumper
25-10722-01	#8 x 5/8 box hd blk ox w s
25-11020-01	10/24 x 3/4 long socket hex, blk fl hd m/s
25-10211-01	#10 internal lock washer
25-10457-01	foam tape
25-11040-01	10 x 32 kep nut
25-10264-01	#10 fender washer
25-11039-01	masking tape black 1" wide
25-11019-01	#10-24 x 1" button head socket screw

Shipping Group

PART NO.	DESCRIPTION
15-10974-01	carton, TAIL GUNNER
72-10919-02	manual, TAIL GUNNER
	lab, packing list envelope

Joystick Assembly

PART NO.	DESCRIPTION
37-10683-01	switch, push button
20-10994-01	ring, pivot
20-10995-01	lever, lower
20-10996-01	lever, upper
20-10997-01	handle, joystick, knurled
20-10998-01	bracket, Gimball
51-10465-01	bot, 5k clutch, EJCIN056P502M
25-11025-01	washer, nylon 1/4 i.d.x 9/16o.d.x.06thk
25-11026-01	mach.screw,1/4-20 x 2"lg.blk hed hd
25-11027-01	screw,#6-32 x 1/4 lg mach screw phil
35-11028-01	pin,1/4"dia x 2.00L6 type c grooved pin
35-11029-01	pin,1/4" diam x 1 1/2" lg type c grooved pin
25-11030-01	1/2 o.d.round spacer #9257-ss257
25-10682-01	#4-40 x 1/8 set screw
35-11031-01	1/4 dia x 3/4 L6 dowell pin, std,s.steel
87-10949-01	joystick harness
20-11000-01	bracket, base joystick, control panel
22-11023-01	lab, overlay, joystick
21-11024-01	floating disk Exidy 75-5161-0
25-10404-01	#10-24 x 1/21g car blt blk
25-10190-01	#10-24 hex nut sm. ptn
25-11032-01	1/4 i.d. x 5/8 o.d. x 3/32 thk washer
25-10437-01	tie mount
25-10227-01	tie wrap

Armrest Control

PART NO.	DESCRIPTION
20-10993-01	fab, armrest panel
37-10683-01	switch, push button
87-10992-01	armrest control harness
22-11022-01	overlay, armrest control

Electronic Drawer

PART NO.	DESCRIPTION
38-10003-01	192 display assembly
38-10001-01	logic board assembly
82-10290-01	power supply
32-10977-03	electronic drawer cab
87-10383-01	ground wire harness
20-10274-01	board mounting plate
87-10005-01	main harness
87-10258-01	16 pin ribbon cable
87-10259-01	34 pin ribbon cable
87-11008-01	harness 8 pin header
38-10922-01	audio board
25-10187-01	6-32 hex nuts
25-10209-01	#6 internal tooth lock washer
25-10410-01	wing nut 10-24
25-10196-01	#6-32 x 1/2 screw pan head, phil
20-10285-01	fab, shield bottom
87-11012-01	assembly harness, top ground braid
87-11013-01	assembly cable, logic to interconnect
25-10729-01	#10 nylon washer
25-10425-01	screw, 10-24 x 3/4 carriage bolt
25-10408-01	standoff 1" 10 x 24
25-10409-01	10-24 x 1/2 m/s hex hd
25-10722-01	8 x 5/8 wood screw
26-10433-01	interlock bracket
25-11018-01	fiber washer #6 x 1/8 or 3/32 o.d
25-11019-01	10-24 x 1 button head socket screw
25-10264-01	310 fenderwasher
25-10211-01	#10 internal tooth lock
25-10190-01	10-24 hex nuts
87-10991-01	power cord
25-10311-01	10-24 x 1 1/2 carriage bolt
37-10434-01	interlock switch

Audio Board Assembly

PART NO.	DESCRIPTION & LOCATION REFERENCES
20-10165-01	heat sink 6072B
20-10216-01	heat sink 6071B
25-10192-01	hex nut #4-40
25-10195-01	mach. screw #4-40x3/8, Phillips
25-10933-01	lockwasher, #4 internal tooth
41-10157-01	con, Molex, 09-18-5062, 6 pin pc, F5(J5)
41-10158-01	con, Molex, 09-18-5069, 6 pin pc, F1(J2)
41-10159-01	con, Molex, 09-18-5094, 9 pin pc, F1(J1,3)
41-10162-01	con, 16 pin, 3M#3408-2202

integrated circuits

44-10137-01	74LS259 (U23)
44-10140-01	74LS393 (U18,8)
44-10143-01	7406 (U28,6)
44-10146-01	7815 (U21)
44-10148-01	7915 (U20)
44-10152-01	TL081 (U1,11,19,2,24,24,25,26,27,3,7,9)
44-10551-01	NE555P (U14,15,16,17)
44-10807-01	74LSSS125 (U4)
44-10808-01	CA308E (U10,13,22)
44-10952-01	7404 (U5)
44-10953-01	74LS123 (U12)
51-10849-01	100K pot, cts#x201R 100K

1/4 w. 5% resistors

53-10054-01	cc,1/4w,5% 100 ohm (R5)
53-10055-01	cc,1/4w,5% 150 ohm (R71,73)
53-10058-01	cc,1/4w,5% 330 ohm (R41,42,46,82)
53-10059-01	cc,1/4w,5%,470 ohm (R3,70)
53-10062-01	cc,1/4w,5% 1 k (R16,22,34,45,60,81,88, 92,93)
53-10064-01	cc,1/4w,5% 2.2 k (R58)
53-10066-01	cc,1/4w,5% 4.7 k (R54,57,61,94)
53-10069-01	cc,1/4w,5% 8.2 k (R12)
53-10070-01	cc,1/4w,5% 10 k (R17,26,30,33,35,59,6, 64,67,8,83,87,91)
53-10072-01	cc,1/4w,5% 20 k (R14,18,32,36,62,65,68,)
53-10073-01	cc,1/4w,5% 30 k (R44,69)
53-10074-01	cc,1/4w,5% 39 k (R19,37)
53-10075-01	cc,1/4w,5% 47 k (R24,76,77,85,23,86,89, 9,90)
53-10076-01	cc,1/4w,5% 68 k (R40)
53-10079-01	cc,1/4w,5% 220 k (R47)
53-10080-01	cc,1/4w,5% 560 k (R43)
53-10081-01	cc,1/4w,5% 1 meg (R1,13,31,7)
53-10648-01	cc,1/4w,5%, 2.7k ohm (R21,27,28,48,49,78, 79)
53-10662-01	cc,1/4w,5%,15k (R66)
53-10664-01	cc,1/4w.5%,150k (R53,84)
53-10824-01	330k,1/4w,5% cc (R11,52)
53-10825-01	360k,1/4w,5% cc (R51)
53-10826-01	390k,1/4w,5% cc (R55)
53-10827-01	470k,1/4w,5% cc (R2,4)
53-10829-01	680k,1/4w,5% cc (R25)
53-10831-01	820k,1/4w,5% cc (R50)
53-10832-01	910k,1/4w,5% cc (R56)
53-10834-01	82k,1/4w,5% cc (R20,38,63,74)
53-10924-01	22k,1/4w.5% cc (R22)
53-10925-01	100k,1/4w,5% cc (R39,80)

capacitors

63-10030-01	tant,dip,25/35v,3.3mf (CCC38,39,40)
63-10032-01	tant,dip, 35v, 1mf (C44,8)
63-10034-01	tant,dip, 35v, 4.7mf (C26)
63-10035-01	tant,dip, 50v, .47mf (C28,29)
63-10038-01	disc, 50v, .01mf (C18,19,20,23,3,30)
63-10041-01	disc, 100v, .1mf (C10,12,13,2,21,27,32,33, 4,42,49,50,51,52,7)
63-10048-01	.022 mf 200v (C9)
63-10215-01	disc, 100v, .005mf (C41,17)
63-10666-01	1k v,470pf,(arco ccd-471) (C34,35,36)
63-10669-01	35v,15uf (spr 196d 156x9035 pe4) (C24)
63-10814-01	.05mf 500v disk Sprague sga-550 (C14)
63-10816-01	100mf 25v electrolytic (C1,5)
63-10818-01	.22mf 35v tant (C25)
63-10820-01	.68mf,35v tant (C6)
63-10926-01	10uf35v tantdip (Sprague 196d106x9035pe3) (C15,16,43
63-10934-01	.01uf 100v film (C11)
63-10935-01	.15uf35v tantdip (Sprague 196d154x9035e3) (C22,31)
63-10026-01	diode,signal 1N914B(D19,2,3,4,5,6,7,8,9,11)
65-10838-01	diode IN5240 (D1)

transistors

66-10011-01	NPN 2N3904 (Q1,10,2,9)
66-10012-01	NPN 2N6292 (Q6)
66-10021-01	PNP 2N3906 (Q3,4,5,8)
66-10022-01	PNP 2N6107 (Q7)
80-10923-01	PCF p.c. board, TAIL GUNNER 2

Universal Coin Door Asy. Comp.

PART NO.	DESCRIPTION
87-10342-01	coin door harness
38-10008-01	coin, meter
26-11033-01	Univ. Coin Door Asy. Exidy Ver. w/lock and acc brkt.
25-10437-01	tie mounts
25-10227-01	tie wraps
25-10187-01	6-32 hex nut
25-10341-01	#6 flat washer
26-10978-01	acceptor, Vendall twenty-five LEDs

Joystick Harness

PART NO.	DESCRIPTION
41-10996-01	plug Molex 9 pin
35-10224-01	pin Molex female
35-10225-01	pin Molex male
34-10468-04	wire 22AWG red
34-10468-01	wire 22AWG violet
34-10468-08	wire 22AWG white
34-10468-05	wire 22AWG orange
34-10468-09	wire 22AWG brown
34-10468-10	wire 22AWG green
34-10468-07	wire 22AWG black
25-10227-01	tie wraps- 4"

Armrest Harness

PART NO.	DESCRIPTION
41-10219-01	plug Molex 03-09-2038 3 Pin
35-10224-01	pin Molex male
34-10468-06	wire 24 AWG yellow
25-10227-01	tie wraps

Control Interconnect Harness

PART NO.	DESCRIPTION
41-10220-01	RECP Molex 03-09-1038 3 pin
41-10219-01	plug Molex 03-09-2038 3 pin
41-10221-01	recp Molex 03-09-1093 9 pin
35-10225-01	pin Molex 02-09-2118 male
35-10224-01	pin Molex 02-09-1118 female
41-10696-01	edge con Molex 09-50-5155
35-10850-01	pin Molex 08-03-0306 edge conn
25-10227-01	tie wraps
34-10468-06	wire 22 AWG yellow
34-10468-09	wire 22 AWG brown
34-10468-10	wire 22 AWG green
34-10468-07	wire 22 AWG black
34-11034-05	wire 22 AWG white/orange
34-10468-02	wire 22 AWG blue
34-10468-01	wire 22 AWG violet
34-10468-04	wire 22 AWG red
34-10468-05	wire 22 AWG orange
34-10468-03	wire 22 AWG grey
34-10468-08	wire 22 AWG white
34-11034-01	wire 22 AWG white/violet

8 Pin Header

PART NO.	DESCRIPTION
41-10228-01	Molex, 6 pin recp. 03-09-1062
36-10515-01	8 pin header DIP
35-10224-01	Molex female pin
34-10469-06	wire 24 AWG
34-10469-01	wire 25 AWG yellow
34-10469-04	wire 24 AWG violet
34-10469-05	wire 24 AWG red
25-10227-01	tie wrap 24 AWG orange

Ground Braid Bottom

PART NO.	DESCRIPTION
04-10301-01	braid copper, tinned 1/4" wide
35-10611-01	pin terminal Panduit R8-14R

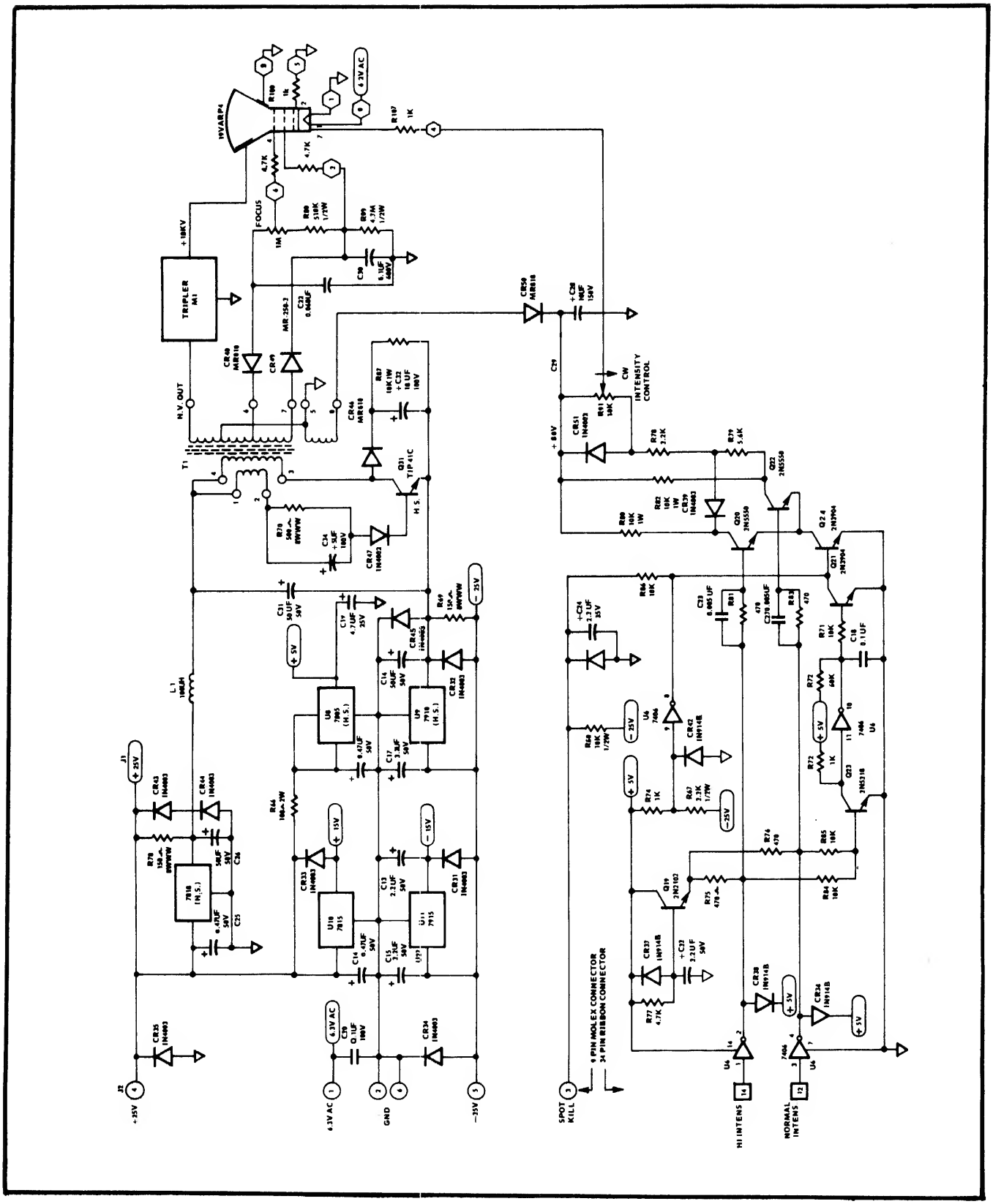
Ground Braid Top

PART NO.	DESCRIPTION
04-10301-01	braid copper, tinned 1/4" wide
35-10611-01	pin terminal (Panduit #P-B-14R)

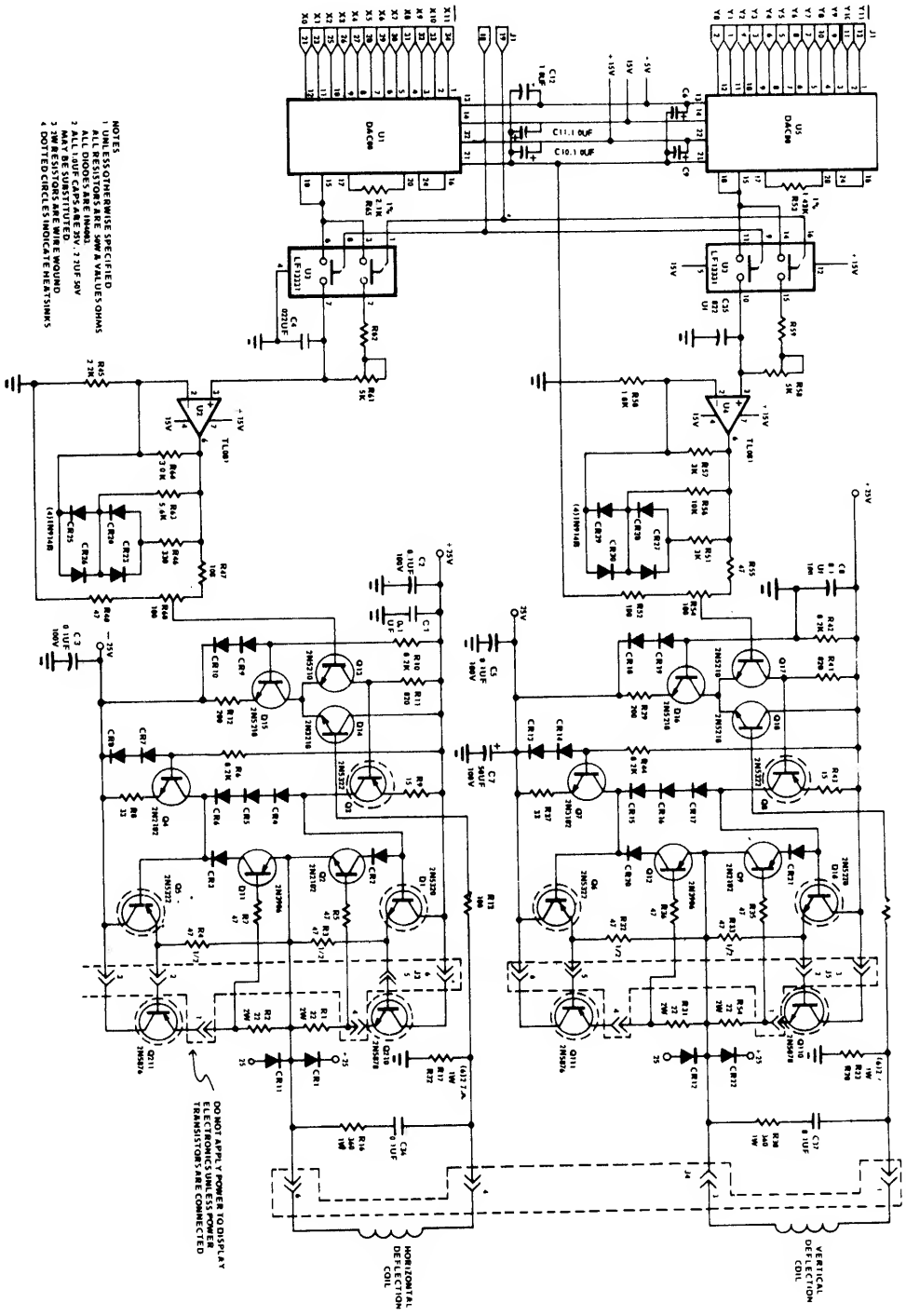
Harness-Logic to Interconnect

PART NO.	DESCRIPTION
80-10671-01	FAB, PLYR select BD
87-10253-01	ASY, 26 pin ribbon cable

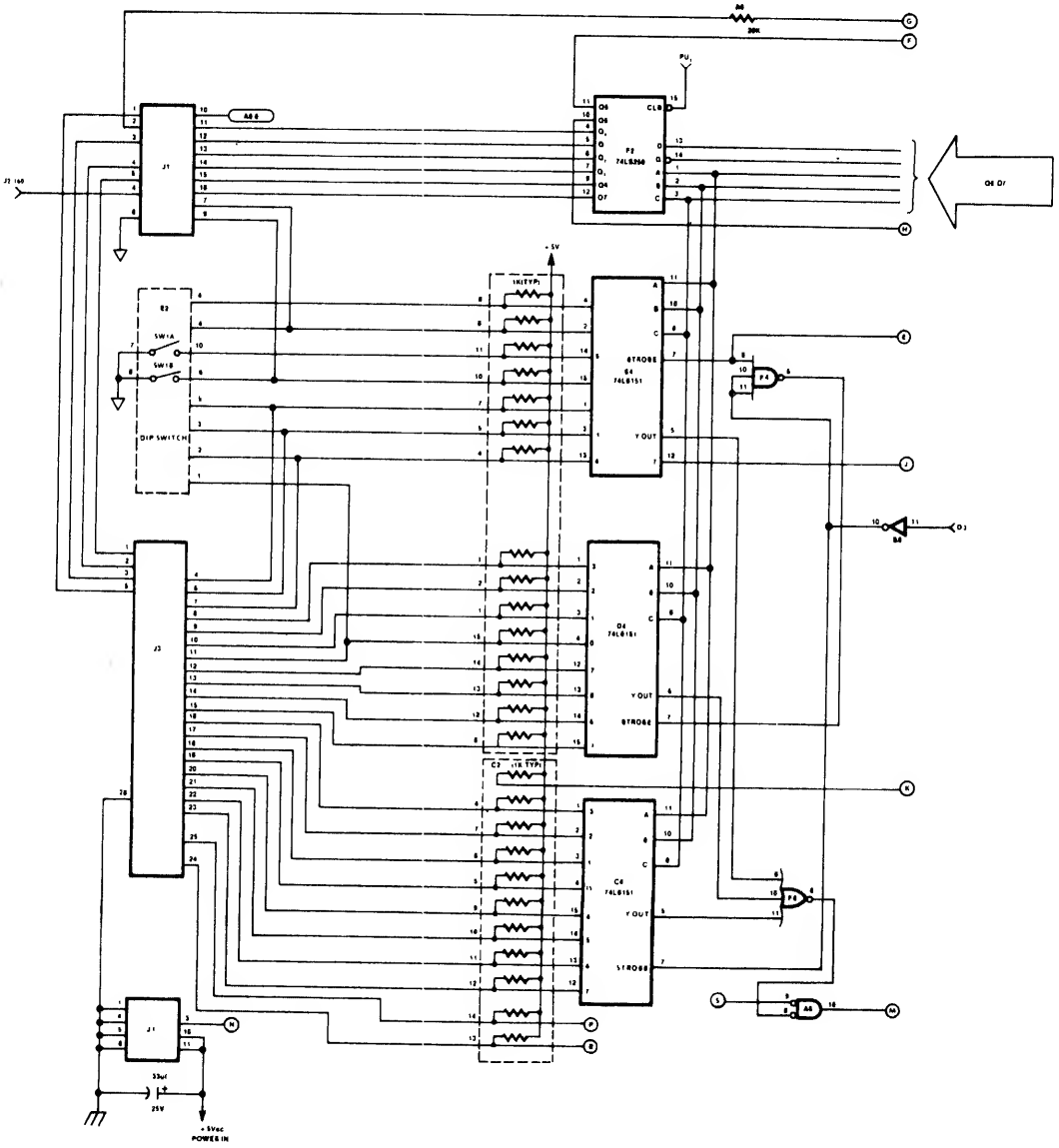
APPENDIX C: Schematics



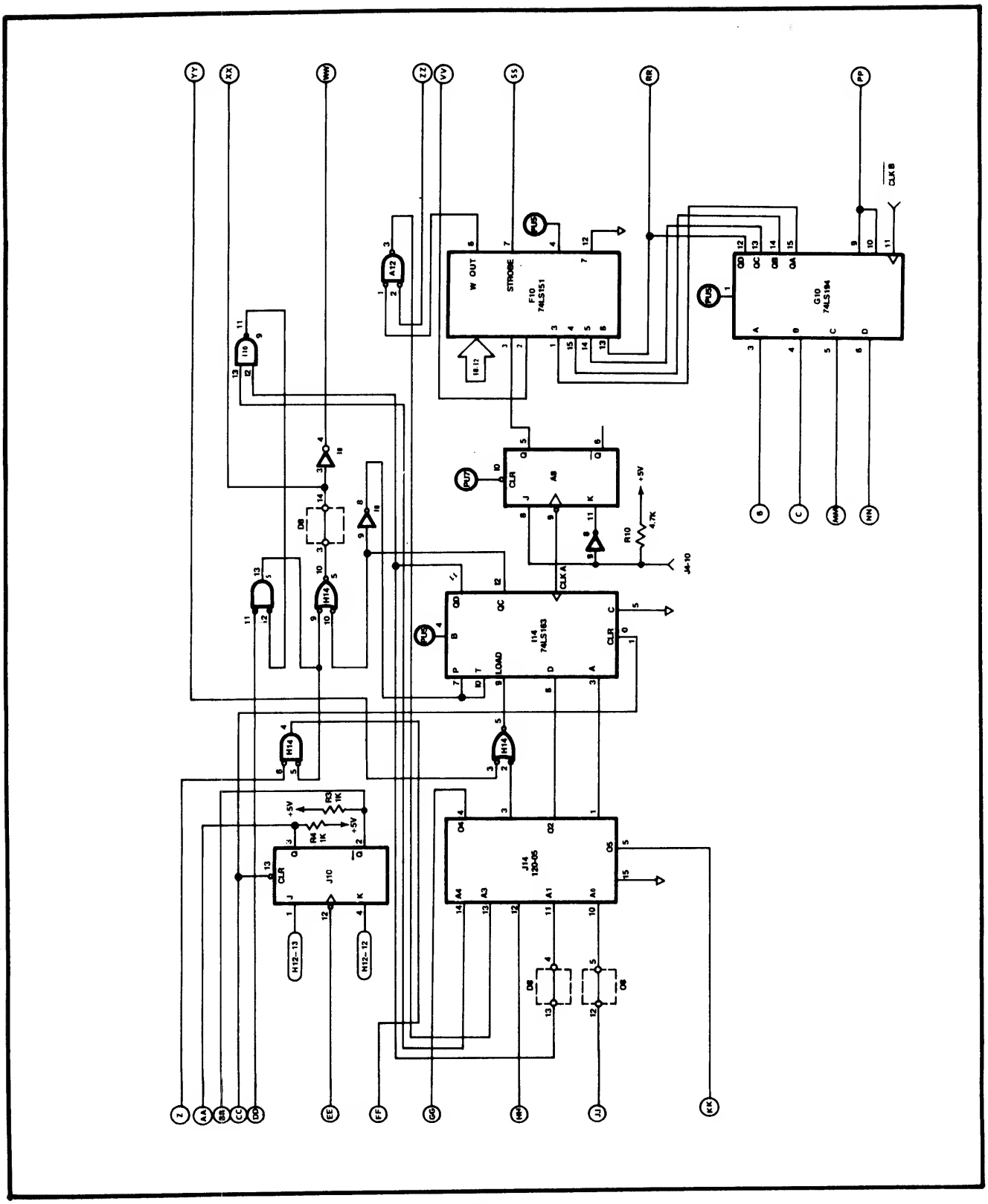
Monitor Display Electronics



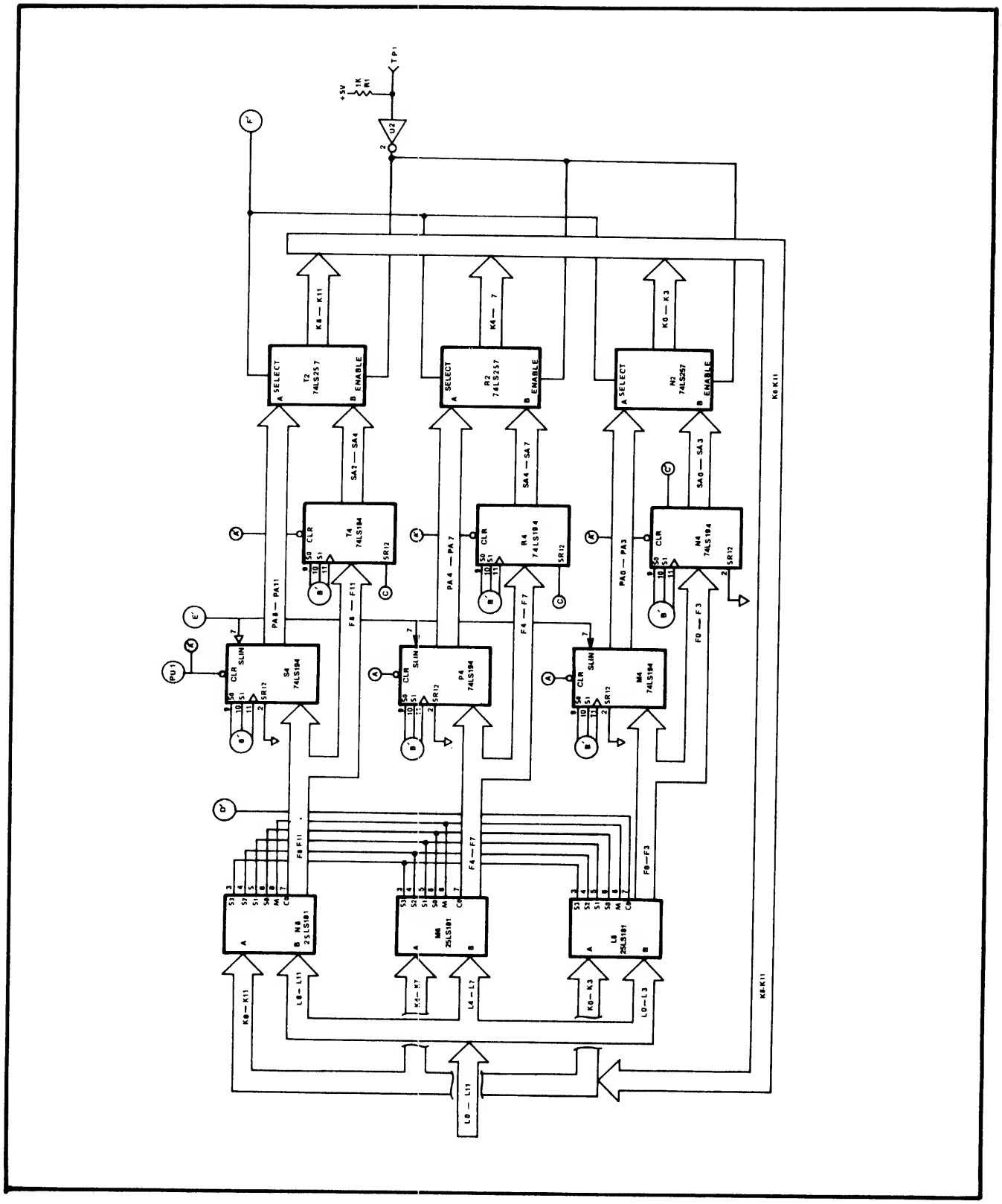
Vector Display Electronics



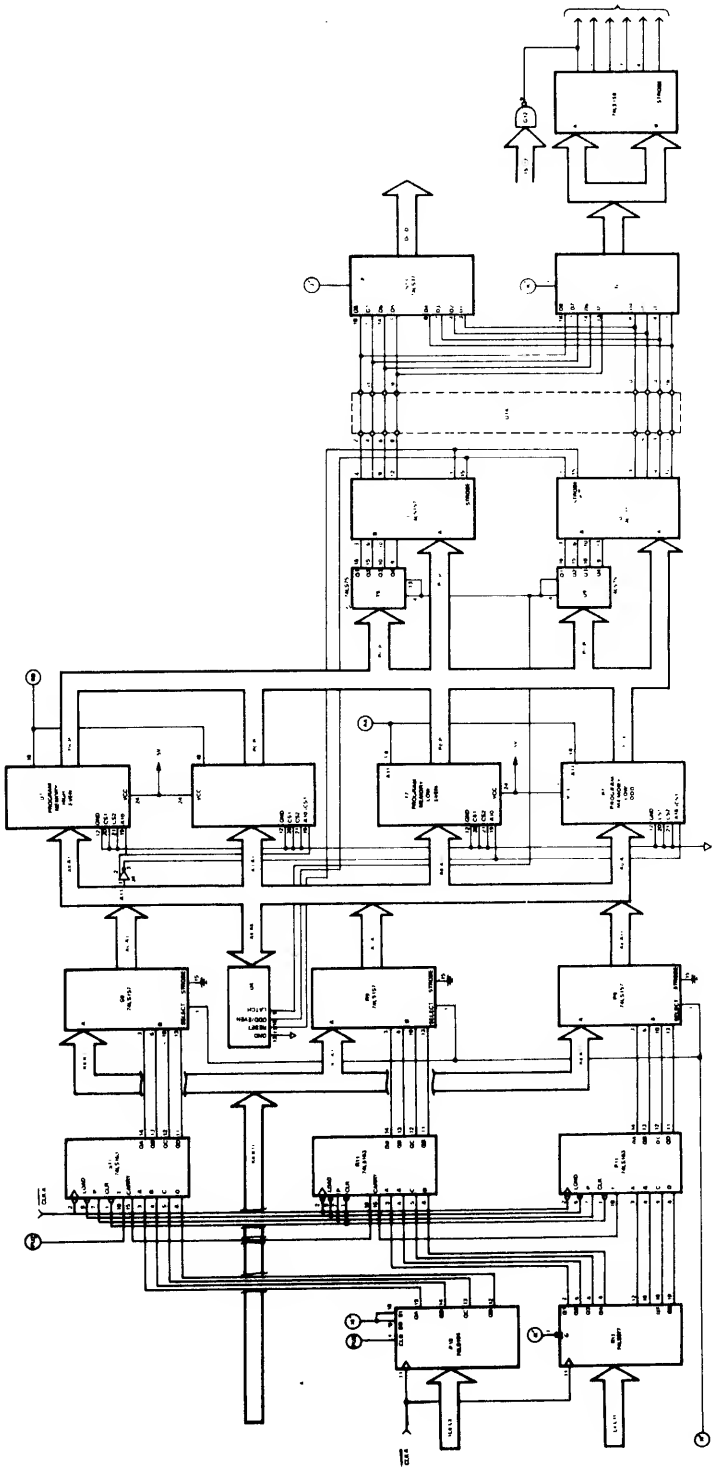
Input/Output Logic



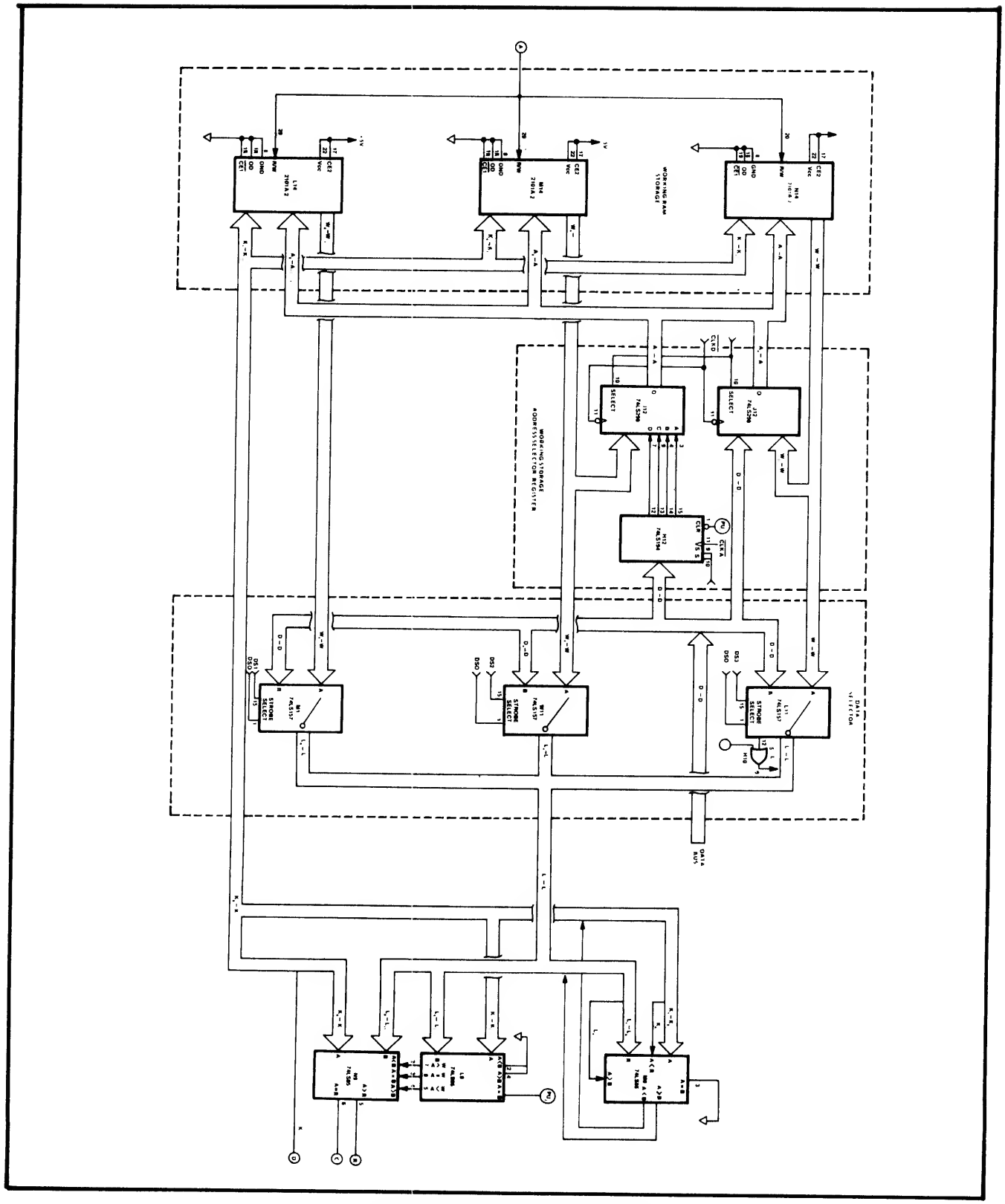
Sequencer Logic



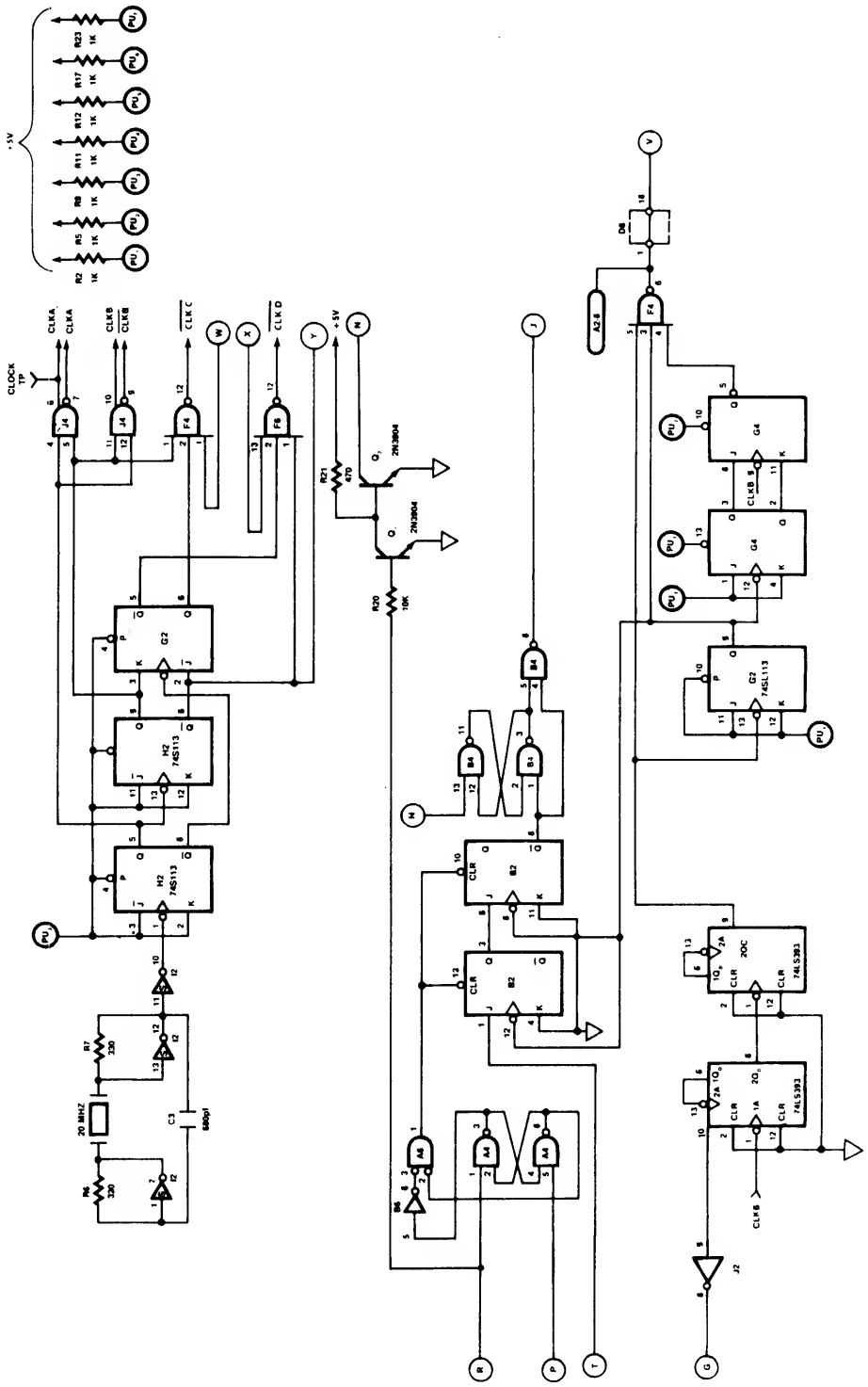
Program Address Counter
Computation Logic



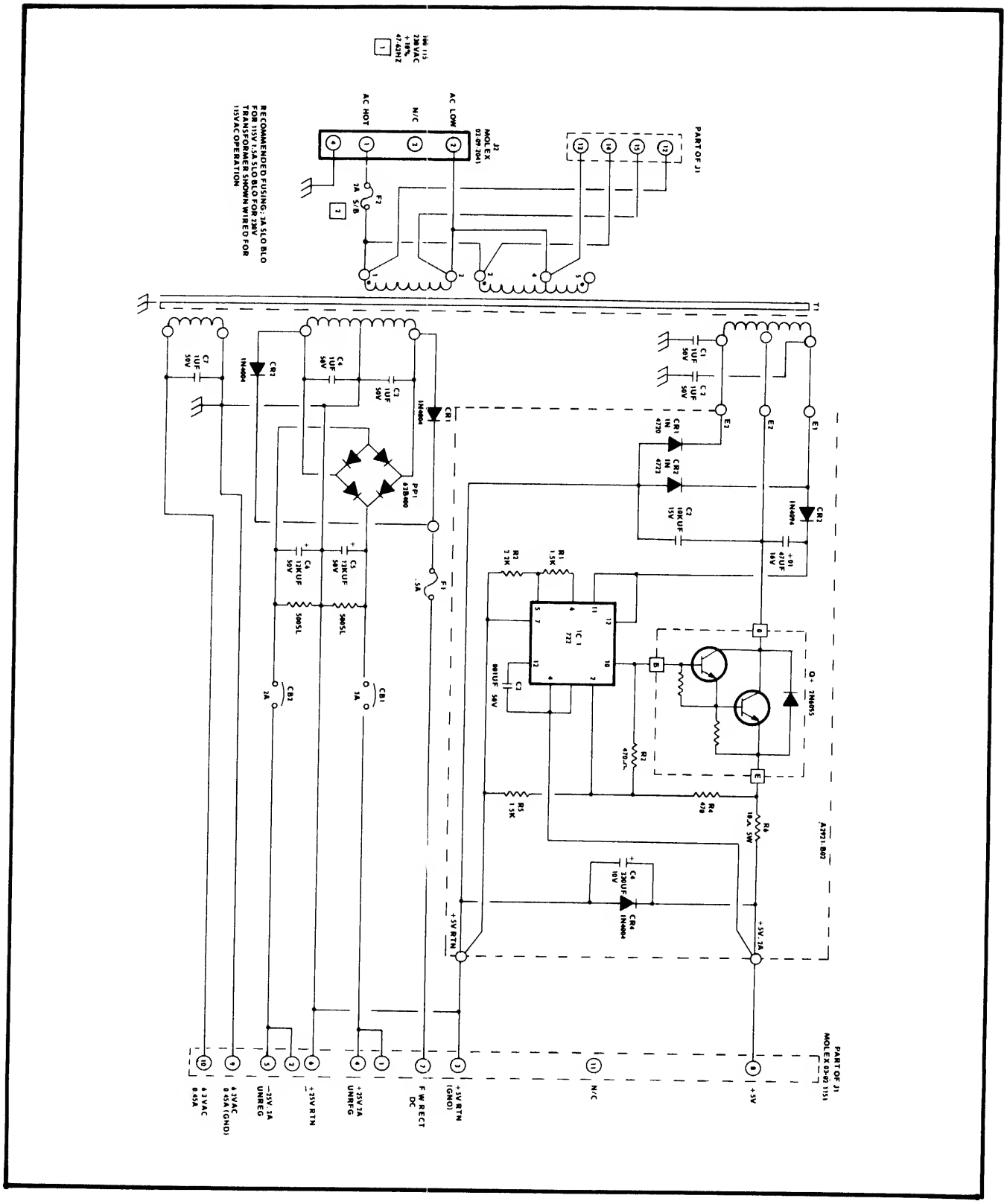
Program Memory, Data Bus Multiplexing
Instruction and Data Register



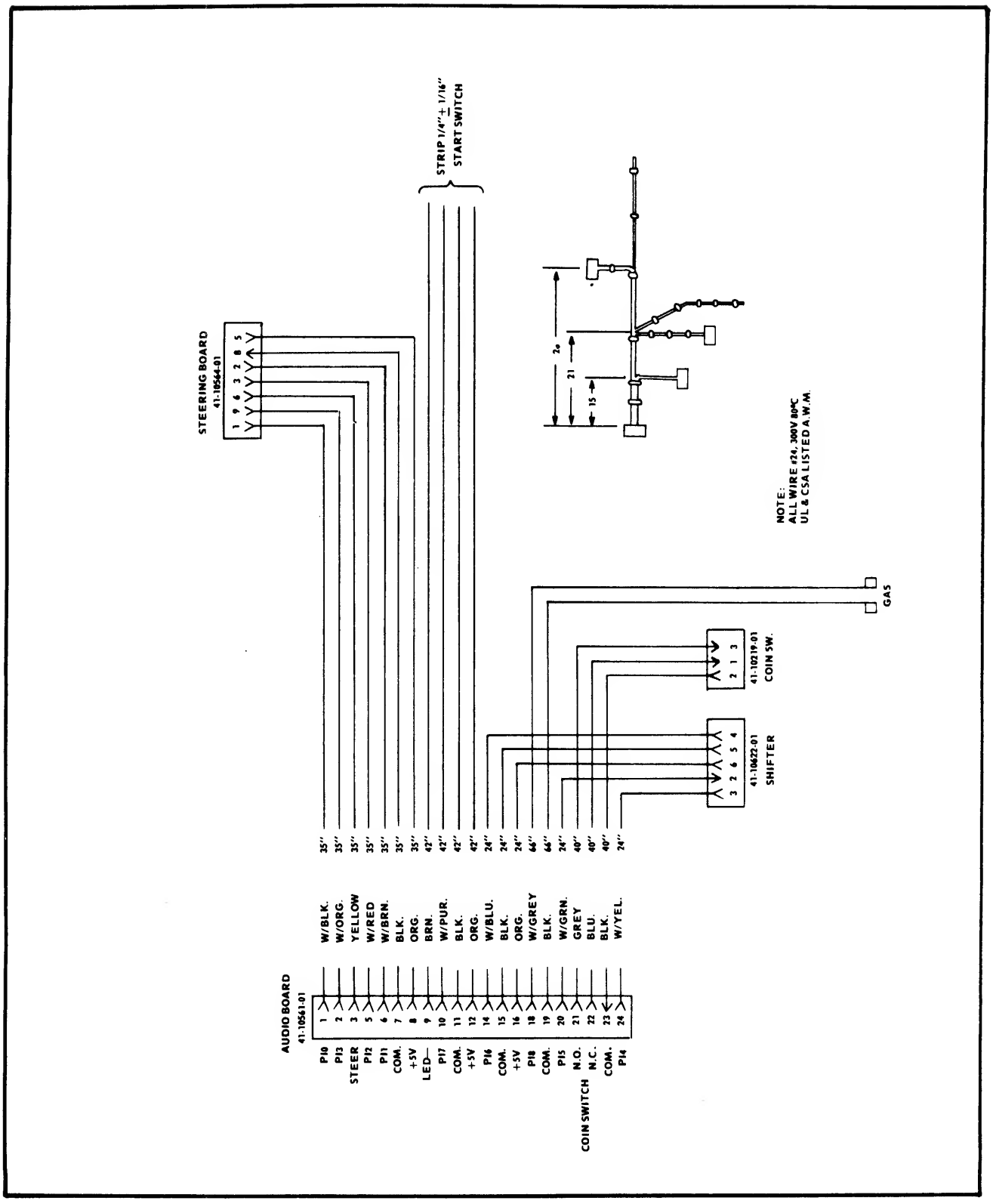
Working Storage, Address Selector
Address Selector, and Data Selector



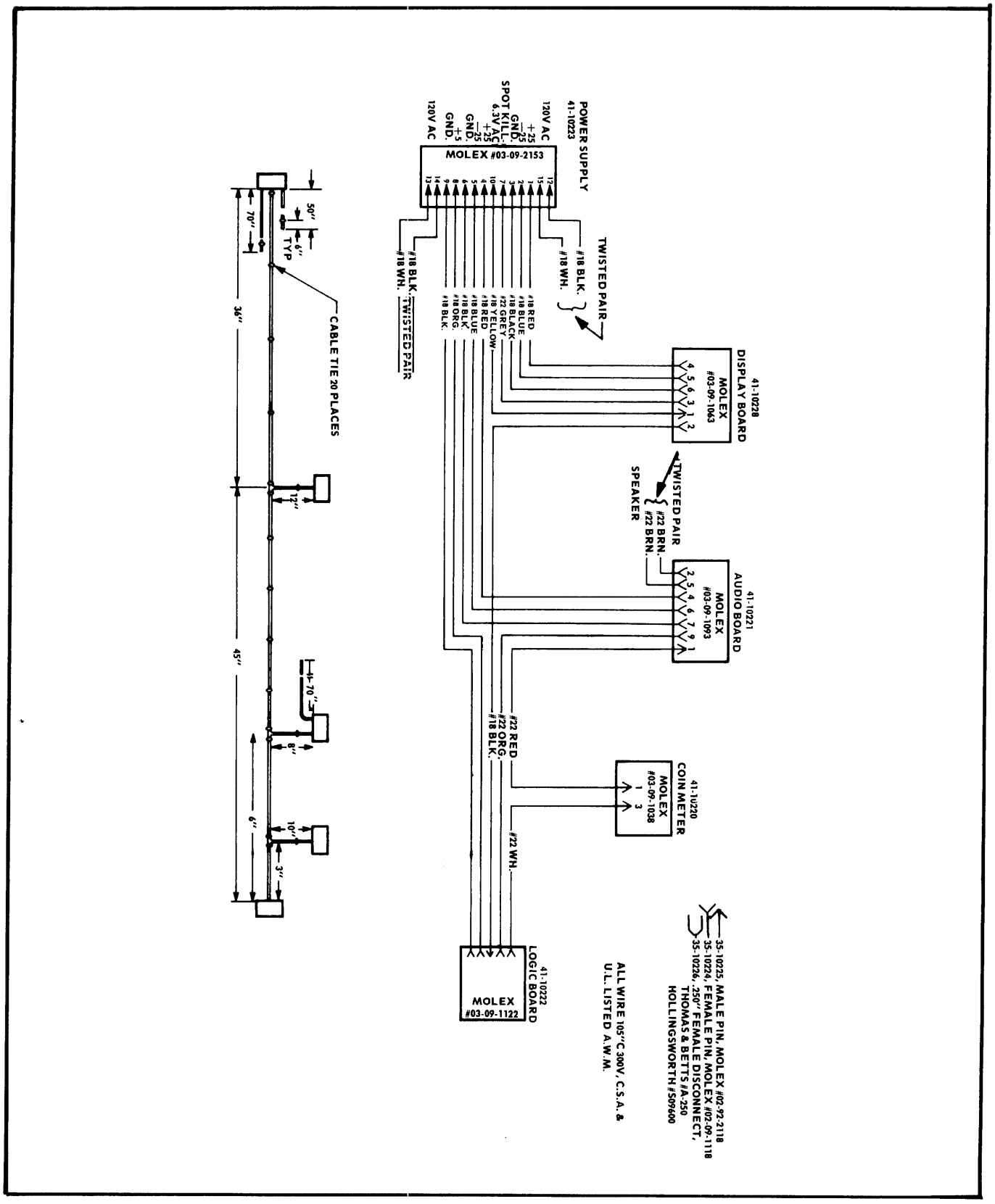
Oscillator/Clock Logic



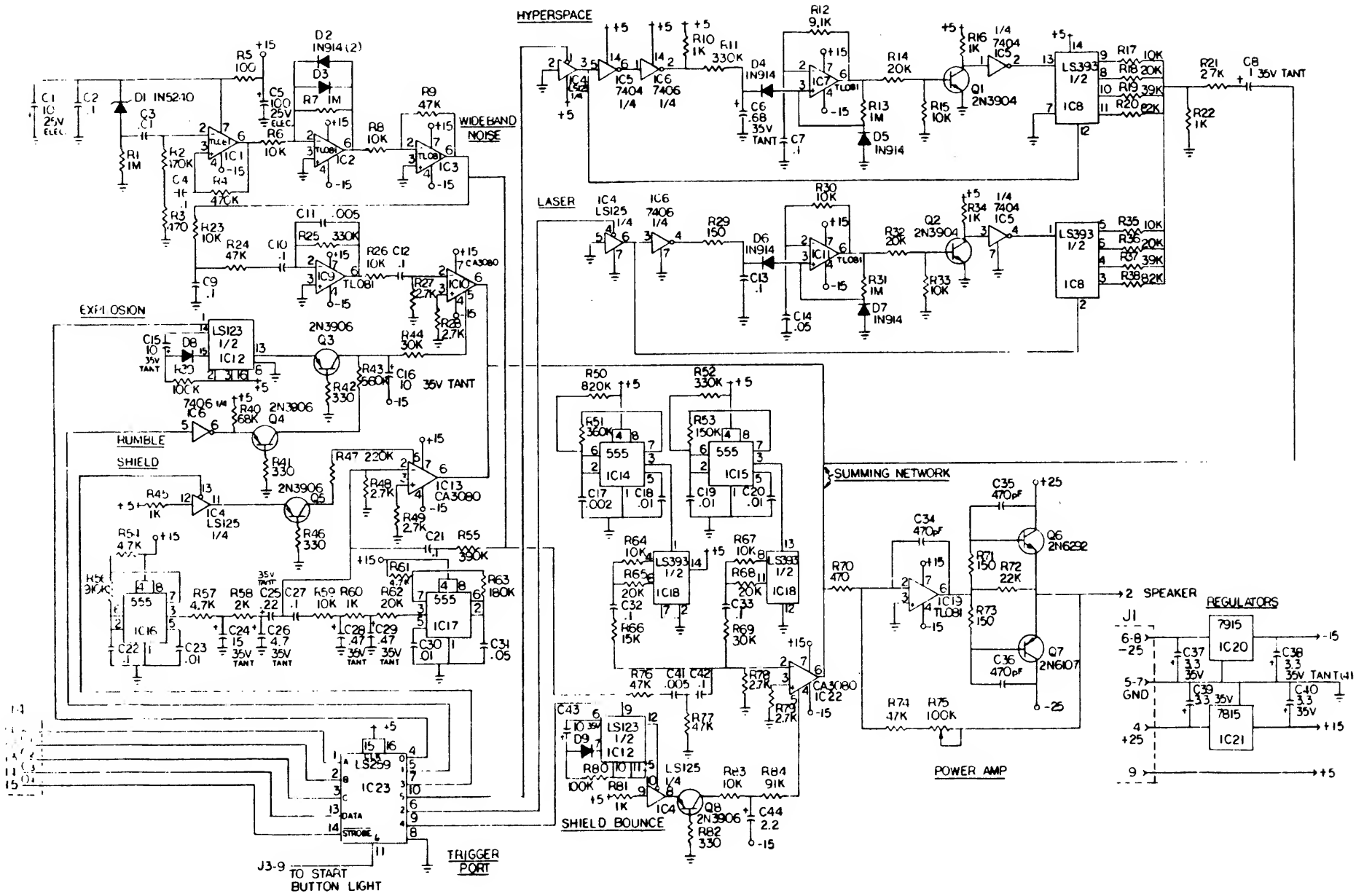
Power Supply Schematic

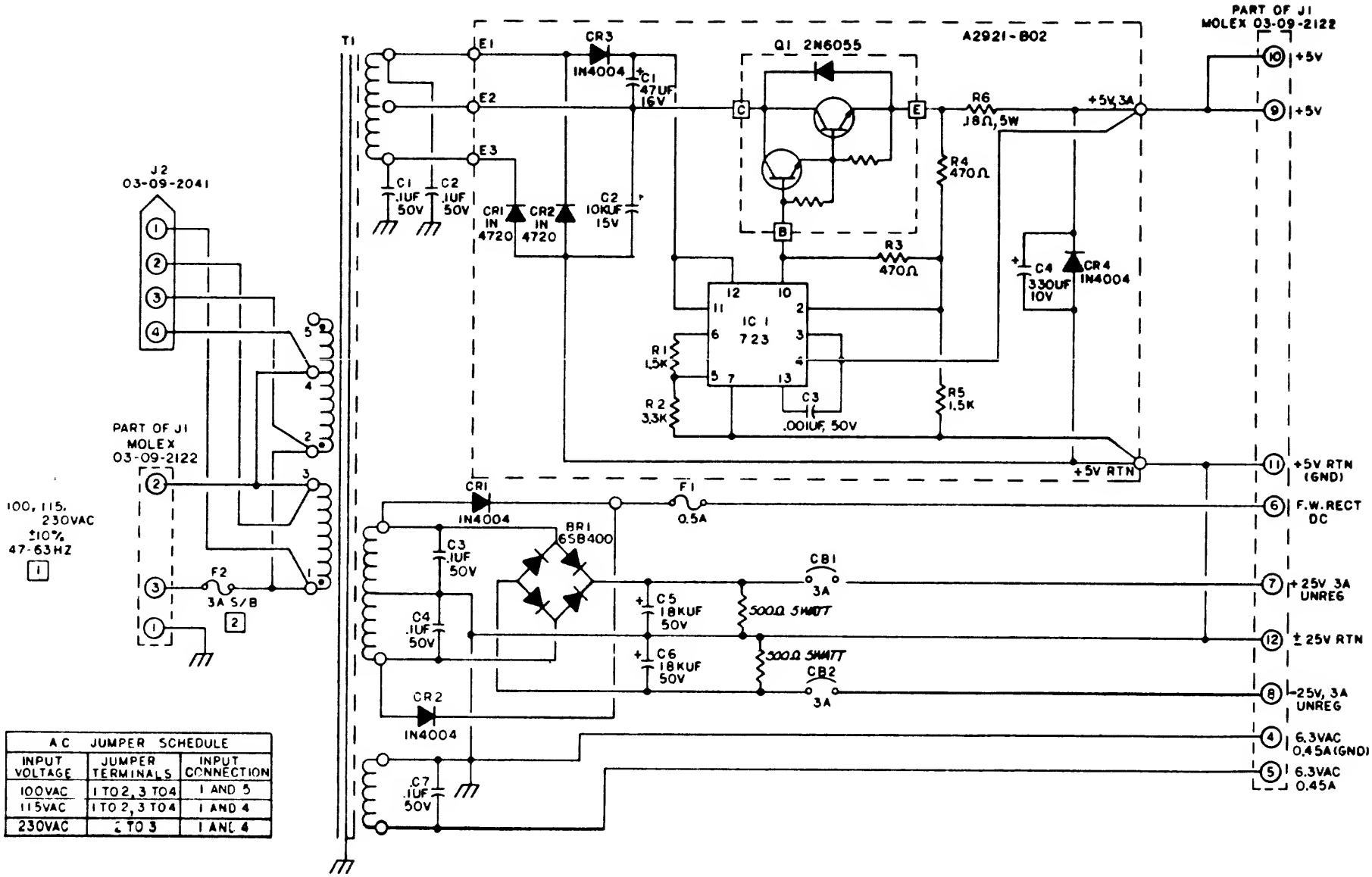


Control Harness

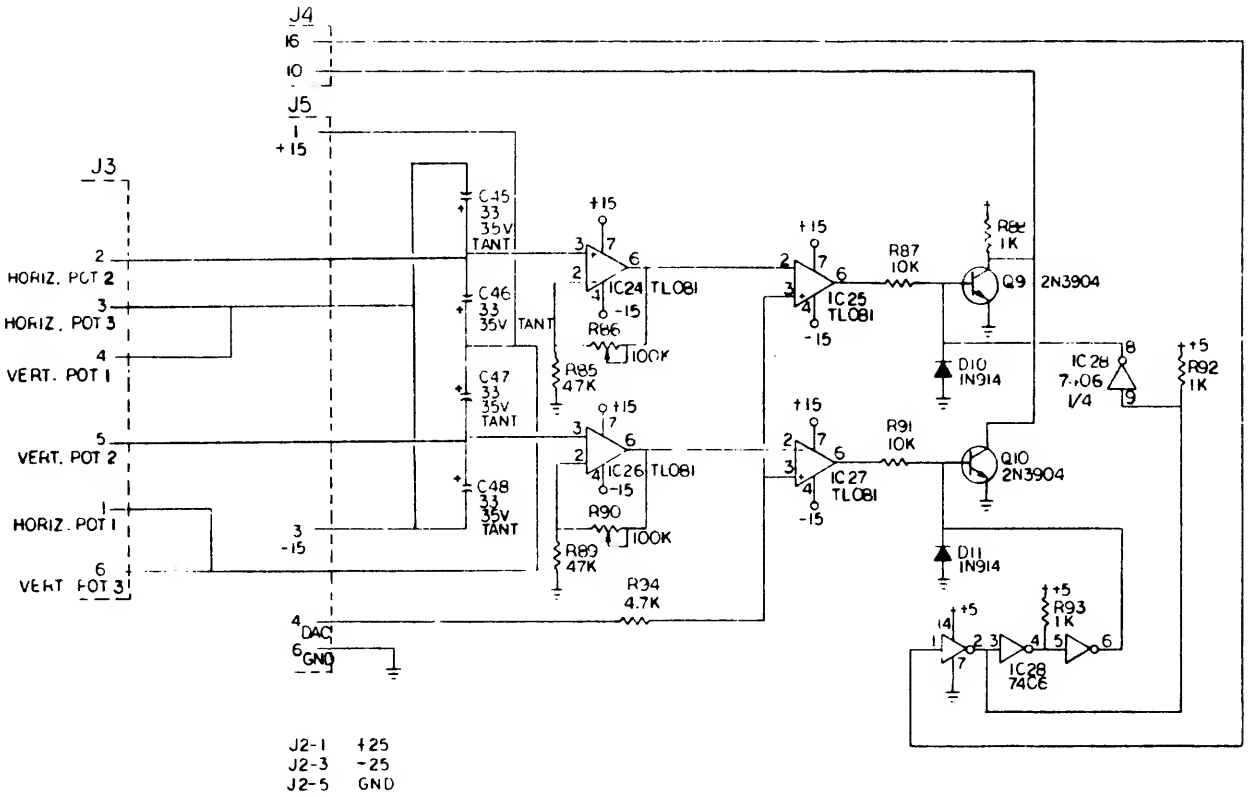


Power Harness


HYPERSPACE
WIDEBAND NOISE
LASER
EXPLOSION
RUMBLE
SHIELD
SHIELD BOUNCE
SUMMING NETWORK
POWER AMP
REGULATORS
2 SPEAKER
TRIGGER PORT
J3-9 TO START BUTTON LIGHT
D1 IN5240
D2 IN914 (2)
D3
D4 IN914
D5 IN914
D6 IN914
D7 IN914
D8
D9
Q1 2N3904
Q2 2N3904
Q3 2N3906
Q4 2N3906
Q5 2N3906
Q6 2N6292
Q7 2N6107
Q8 2N3906
IC1 TL081
IC2 TL081
IC3 TL081
IC4 LS125 1/4
IC5 7404 1/4
IC6 7406 1/4
IC7 TL081
IC8 LS393 1/2
IC9 TL081
IC10 CA3080
IC11 TL081
IC12 LS123 1/2
IC13 CA3080
IC14 555
IC15 555
IC16 555
IC17 555
IC18 LS393 1/2
IC19 TL081
IC20 7915
IC21 7815
IC22 CA3080
IC23 LS259
J1
+15
+5
-15
+25
-25
GND

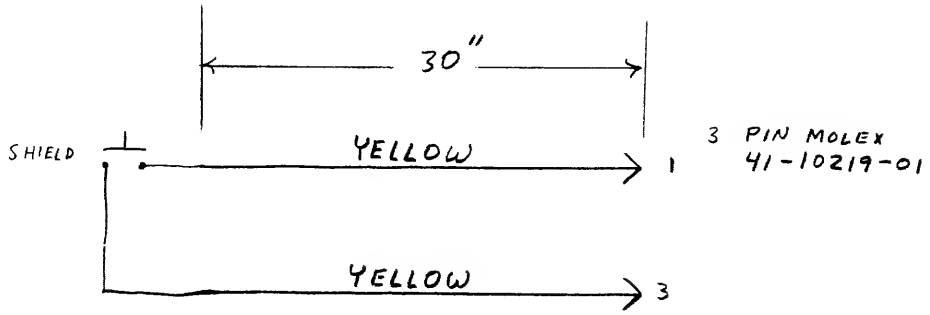


AC JUMPER SCHEDULE		
INPUT VOLTAGE	JUMPER TERMINALS	INPUT CONNECTION
100VAC	1 TO 2, 3 TO 4	1 AND 5
115VAC	1 TO 2, 3 TO 4	1 AND 4
230VAC	2 TO 3	1 AND 4



JOYSTICK CIRCUITRY

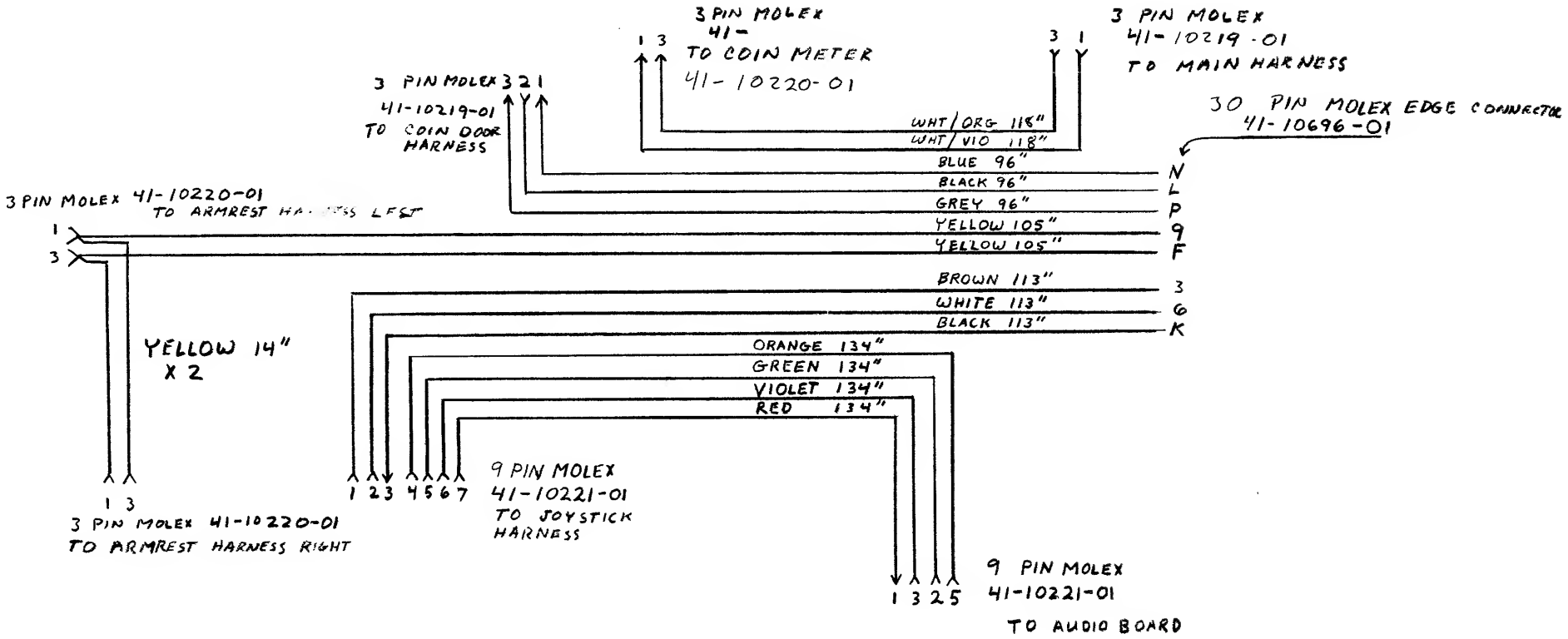
1. ALL DIODES ARE IN914 UNLESS OTHERWISE SPECIFIED.
3. C39 C50 AND C51 ARE BYPASS CAPS (.1uf, 50V) FROM GROUND TO +5V
2. ALL RESISTOR VALUES ARE IN OHMS 1/4W. 5% UNLESS OTHERWISE SPECIFIED.
1. ALL CAPACITOR VALUES ARE IN MICROFARADS, 50V. MYLAR UNLESS OTHERWISE SPECIFIED.



ALL WIRE AWG 20
CSA APPROVED ECT

USE 4" TIE WRAPS
AS REQ'D

ARMREST HARNESS
87-10992-01

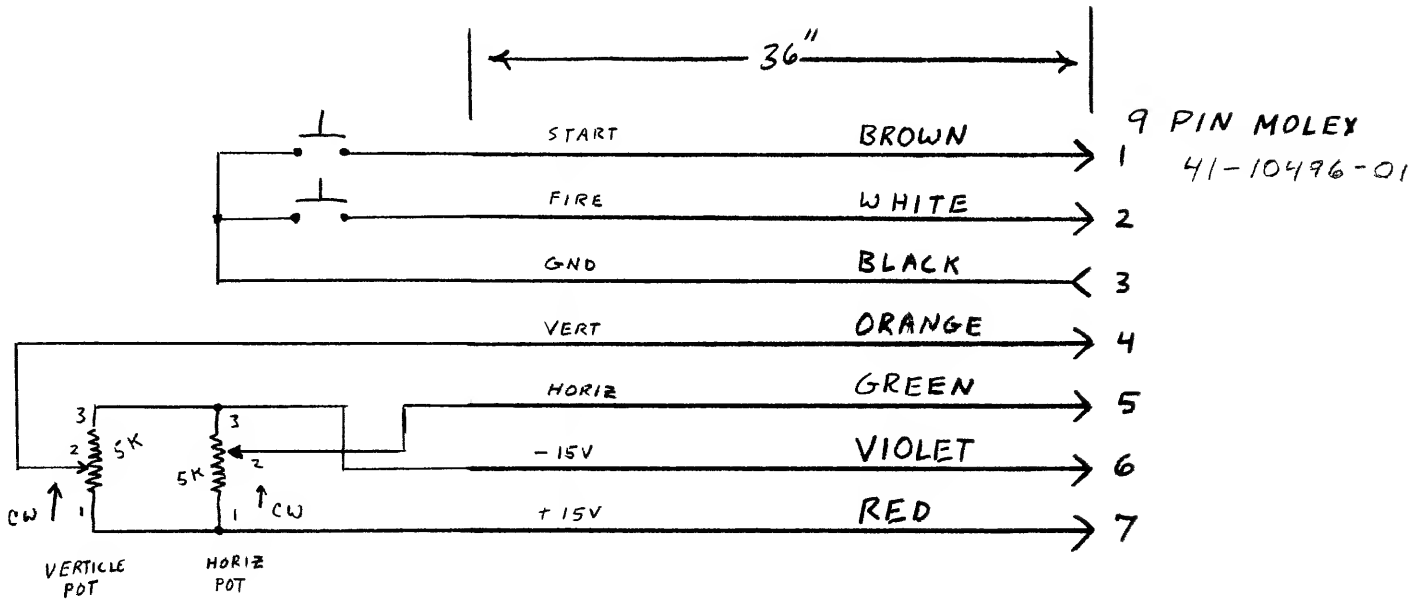


ALL WIRE AWG 20

CSA APPROVED Ect

USE 4" TIE WRAPS AS REQ'D

CONTROL INTERCONNECT HARNESS 87-11001-01



ALL WIRE AWG 20

CSA APPROVED

USE 4" TIE WRAPS AS REQ'D

JOYSTICK HARNESS

87-10949-01